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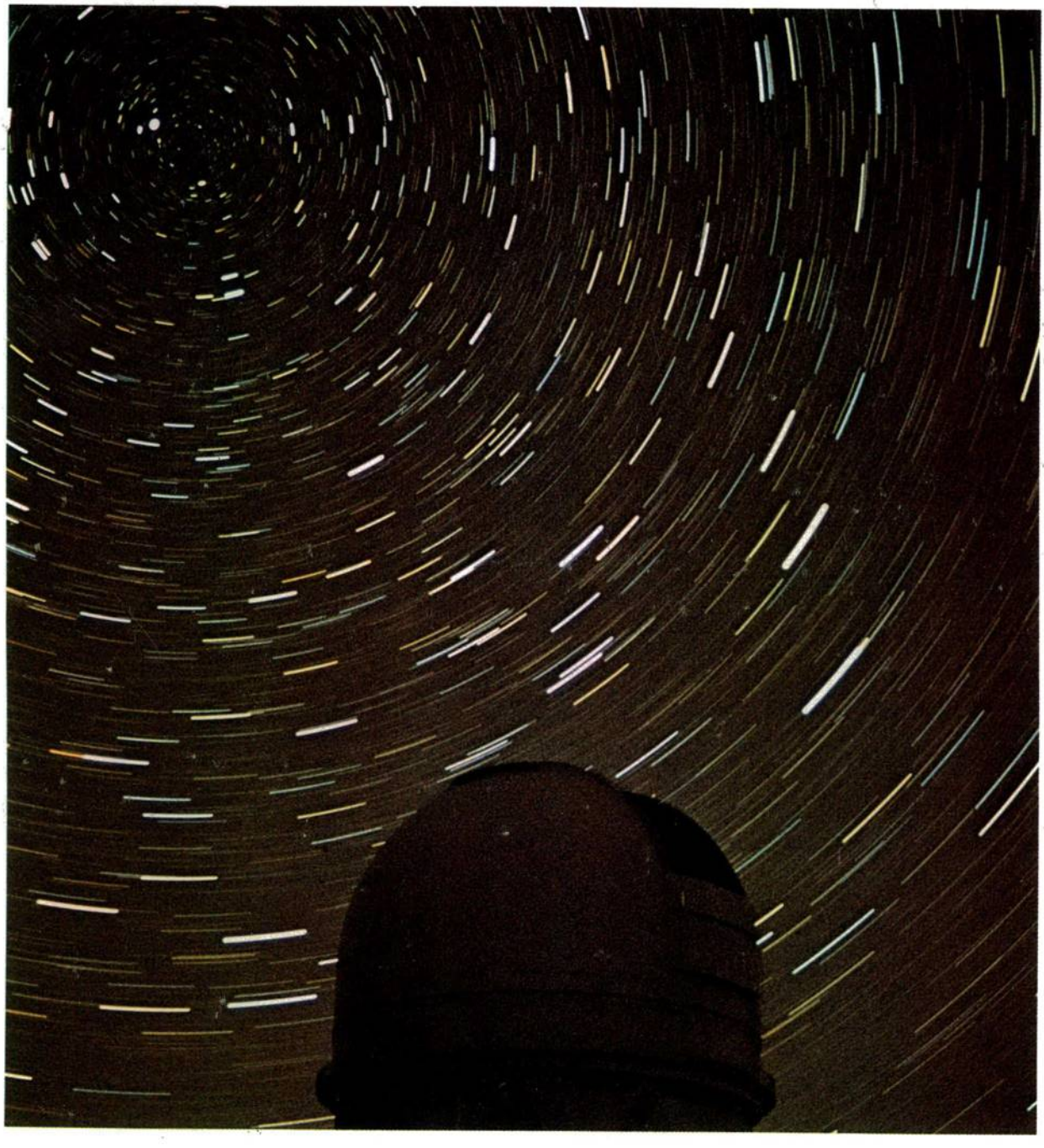

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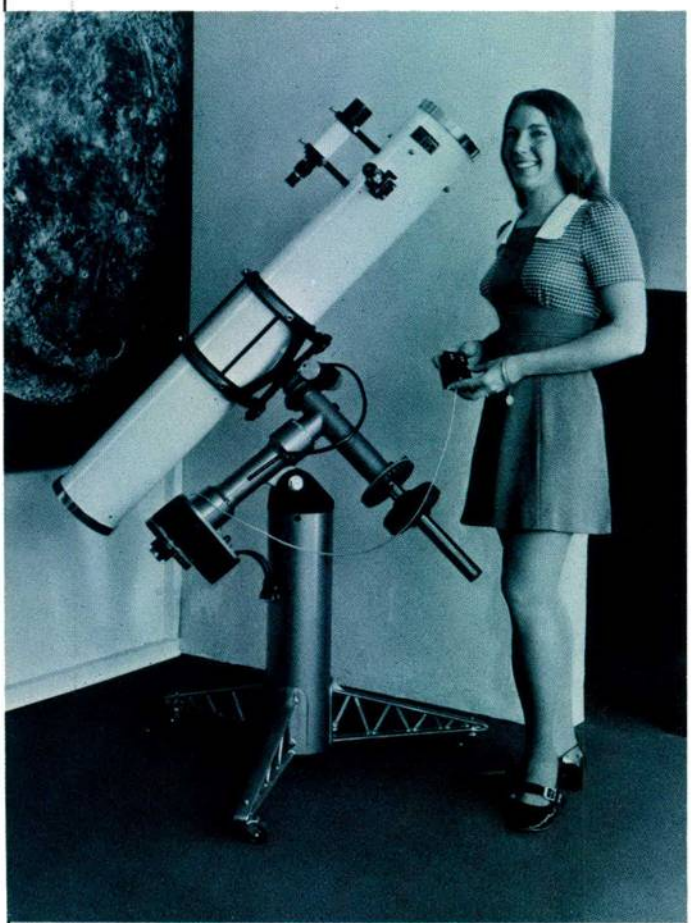

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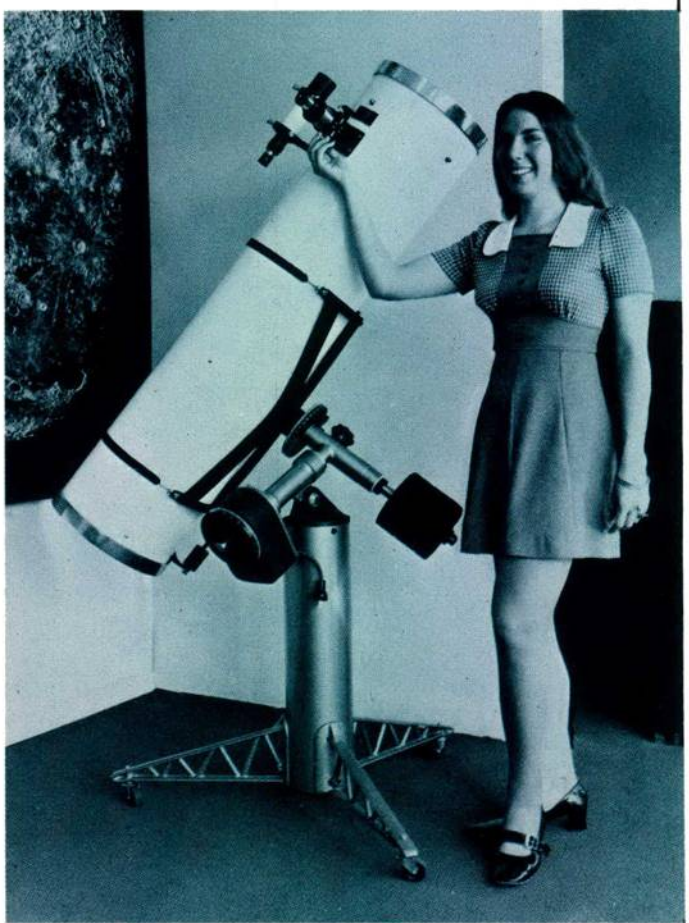

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ASTRONOMY

The World's Most Beautiful Astronomy Magazine

November 1974 Vol. 2, No. 11

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Cover
Photograph by Steve Grandi

The myriad stars silently wheel above the giant dome that houses the world's second largest telescope — the new 158 inch reflector of Kitt Peak National Observatory. A recent photo taken with that telescope is displayed in the centerfold of this issue. No giant observatory telescope was required for the cover photo however — just an ordinary tripod-mounted 35mm camera with a 55mm f/1.9 lens. The camera's shutter was left open for about 30 minutes — long enough for Earth's rotation to swing the stars in small arcs. Polaris is so close to the north celestial pole that it hardly moved and was recorded as a stubby bright blob at upper left. The High Speed Ektachrome film was processed at ASA 400.

Published monthly by AstroMedia Corp., 757 North Broadway, Suite 204, Milwaukee, Wisconsin 53202. Telephone (414) 276-2689. Copyright © 1974 by AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or otherwise copied for public or private use without written permission of the publisher.

Second class postage paid at Milwaukee, Wisconsin.

Direct all subscription correspondence, new subscriptions, changes of address and complaints to ASTRONOMY, Circulation Services, 640 North LaSalle Street, 6th Floor, Chicago, Illinois 60610. Allow six to eight weeks for address change to take effect.

Cover price, $1.50. Subscription price: 1 year, $12.00; 2 years, $22.00; 3 years, $30.00. Canada and Mexico: add $3.00 per year. All other foreign: add $6.00 per year.

POSTMASTER: When undeliverable, send form 3579 to publisher.

Typesetting by Grafilm, Inc., Milwaukee, Wisconsin 53210; Separations prepared by American Color Systems, New Berlin, Wisconsin 53005; Printed by E. F. Schmidt Co., Menomonee Falls, Wisconsin 53051.

NEW JOVIAN VISTAS

Jupiter's Great Red Spot — a towering whirlpool covering an area equal to the entire surface of Earth — is the target for an instrumented balloon probe of the 1990s. The probe's altitude is controlled by changes in the temperature of its sensor laden, hydrogen gas bag. Hurricane force winds swirl ammonia clouds around the sides of the spot, but for centuries the red oval has endured.

Artwork by Rick Sternbach

Sternbach

Winds of 300 m.p.h. whip up storms that could swallow the continent of Asia. Lightning bolts capable of vaporizing a city the size of New York rip open the sky. A surging volcano-like hurricane larger than the planet Earth has been raging for centuries and shows no sign of abating. Above it all, lethal radiation permeates the surrounding environment.

This is Jupiter — half star and half planet — a bizarre colossus that dwarfs every standard of comparison familiar to earthlings. Jupiter's visible surface is 24 billion square miles in area. It's an endless maelstrom of clouds — so vast that if Earth were peeled like an orange the skin would not quite cover the Great Red Spot. The mass of the planet is 318 times the mass of Earth, but the stuff it is made of has extremely low density — 1/ 4 of Earth's or 1.3 times the density of water. The big planet is made up of a mixture of elements similar to that in the sun or the primordial gas cloud which formed the sun and planets. This means very large proportions — possibly 98 percent — are the light gases hydrogen and helium.

Seen from Earth, Jupiter is the fourth brightest object in the sky after the sun, moon and Venus. At five times Earth's distance — 480 million miles — the great world ponderously navigates a huge 12 year orbit about our sun. During its circuits it drags along a dozen moons, two of which are larger than the planet Mercury.

Jupiter completes a rotation once every 10 hours, the shortest day of any of the nine planets. Because of its size, a point at Jupiter's equator races along at 22,000 m.p.h. (compared to a speed of 1,000 m.p.h. for a similar point on Earth). This tremendous rotational speed (and fluid character of the planet) makes Jupiter bulge at its equator resulting in a polar diameter of 82,960 miles — about seven percent smaller than its equatorial diameter of 88,730 miles.

Jupiter's size is mind boggling. More than 10 times the diameter of Earth, the king of planets would fill more than 1/ 3 the distance that separates Earth and the moon. In volume Jupiter exceeds 1,000 Earths.

This month a 570 pound robot from Earth is hurtling at 30,000 m.p.h. in a daring sweep to within 29,000 miles of the colossal planet. When that closest approach occurs on Dec. 3, 1974, Pioneer 11 will be speeding over the night side of Jupiter at a scorching 110,000 m.p.h. — the highest velocity ever achieved by a spacecraft.

The immense gravitational attraction of Jupiter is responsible for the tremendous acceleration of Pioneer 11. The giant planet's gravity will fling the spacecraft back almost in the opposite direction from which it came so that it will be, after the encounter, on a lofting course over the solar system toward the planet Saturn.

Jupiter is the most dangerous planet to visit — even for an unmanned spacecraft like Pioneer 11. Pioneer 10 did it last December, successfully snapping 80 photos of the wind-swept clouds that enshroud the solar system's largest planetary body. But Pioneer 10 stayed three times farther away from Jupiter than Pioneer 11 is going to be at its closest approach.

There is a possibility that the radiation zone that surrounds Jupiter — by far the strongest of any planet — could disable the spacecraft. Pioneer 11's trajectory differs from that of its predecessor in that it will be zooming in toward Jupiter from below and will loop around behind the planet and speed away from above. This maneuver is required to send it on to Saturn, and also helps to cut down exposure in the equatorial region, the deadliest part of Jupiter's radiation zone.

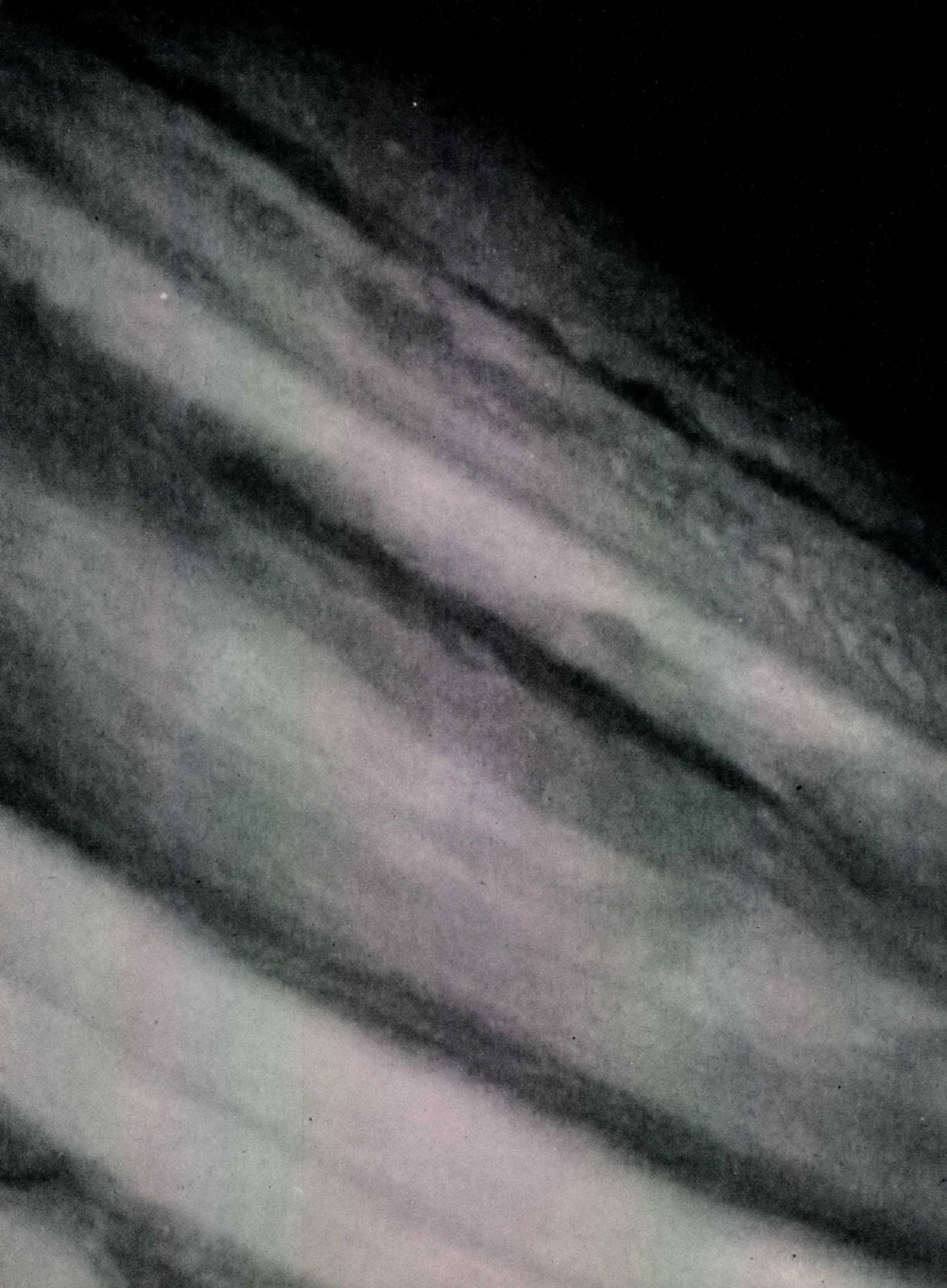
Because Pioneer 11's path will be through uncharted territory, it is expected that it will fill some gaps in our knowledge of the structure and intensity of Jupiter's radiation belts which girdle the equatorial regions of the planet like a giant doughnut (at least that's the way we think they are shaped). This polar pass of Pioneer 11 should flesh out our skeletal knowledge of other aspects of the Jovian environment thus paving the way for a 1980 Jupiter orbiting mission.

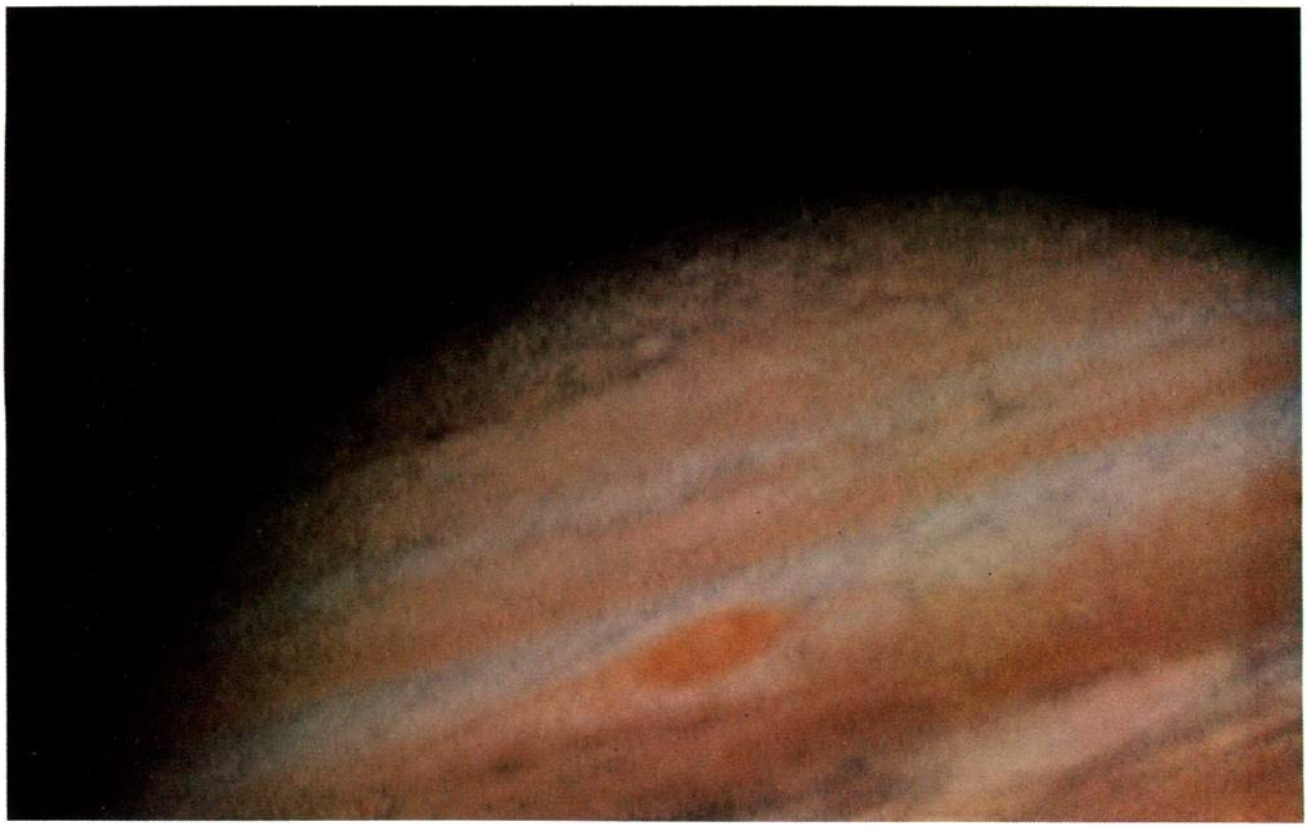
The spectacular photos taken by Pioneer 10 should be duplicated by this year's mission except that the viewing angles will be significantly different, allowing us to look at the never-before-seen polar regions of Jupiter.

Looking back on man's first encounter with Jupiter — the mission of Pioneer 10 last December — refined analysis of the information sent back from that spacecraft has brought into focus a new picture of Jupiter that confirms some earlier concepts of the planet but shatters others.

The information returned by Pioneer 10 seems to support the theory that the largest planet in the solar system is largely a spinning ball of liquid hydrogen without any detectable solid surface. In many respects Jupiter is more like a star than a planet. At best, it has only a

From only 506,000 miles above Jupiter's cloud deck, Pioneer 10's electronic camera system captured never-before-seen structured detail on the giant planet. The wide white band in the lower part of the photo is the south tropical zone. Above it are the dark, complex equatorial belts. The darkest regions are believed to be troughs of descending clouds while the light zones are higher, cooler cloud decks.
NASA Photograph





NASA Photograph

The Little Red Spot in the north tropical zone of Jupiter had been seen by Earth based observers for at least six months prior to the Pioneer 10 observations, but its detailed structure was revealed for the first time in this view of Jupiter taken by Pioneer 10 from 836,000 miles away. The structure inside the spot is similar to that seen within the Great Red Spot which is in the south tropical zone. The importance of the Little Red Spot is that it takes away some of the uniqueness of the Great Red Spot and therefore forces theoreticians to make interpretive "spot models" that can occur at various places on the surface of Jupiter. Pioneer 10 flew past Jupiter in Dec. 1973, and is now headed out of the solar system. A sister spacecraft, Pioneer 11, will reach Jupiter in Dec. 1974.

small rocky core thousands of miles below the heavily clouded atmosphere. The structure of the planet from the highest levels of its atmosphere down through its center is much more accurately known now than at any time in the past because of the Pioneer findings.

Let's suppose we are thousands of miles above the ocean of clouds that blankets the visible surface of Jupiter. Looking down from this vantage point the turbulence of the atmosphere is obvious. Everywhere the clouds are billowing and surging as if they are being stoked by some Jovian furnace far below.

Descending to within 100 miles of the cloud tops we pass through rarified haze layers of ethane and acetylene. A further descent through the hydrogen and helium atmosphere (which has some ammonia and methane mixed in) would plunge us into streaming white clouds similar in appearance to earthly cirrus clouds. These are the brilliant white ammonia ice crystal clouds visible in amateur astronomers' telescopes back on Earth as wide white "zones" on the planet. The most prominent zone, the abode of the Great Red Spot, is called the south tropical zone. Since the atmospheric pressure at the top of the ammonia clouds is about 70 percent of the atmospheric pressure of the surface of Earth, an instrumented exploration probe suspended by a balloon inflated with heated hydrogen could hover here indefinitely. The temperature at this level is -184 degrees Fahrenheit, and a controlled descent would be possible for this 1990s exploration project (pictured on page 4). The temperature about eight miles above the cloud tops, at the 30 percent atmospheric pressure level, is -230 degrees.

Twelve miles below the tops of the white ammonia cloud decks are brownish-orange belts of ammonia hydrosulphide crystals. These belts alternate with the higher level zones and constitute the two main features of the planet's clouds. The tops of the dark belts are 15 degrees warmer than the average upper reaches of the bright zones of ammonia clouds.

Jupiter's relatively permanent belts and

zones appear to be comparable to the continent-spanning cyclones and anticyclones which produce most of the weather in Earth's temperate zones. On both planets, these phenomena are huge regions of rising or falling atmosphere powered by the sun (and in Jupiter's case also by its internal heat source that we will discuss shortly).

On Earth, huge masses of warm, light gas rise to high altitudes, cool off, get heavier, and then roll down the sides of new, rising columns of gas. The general direction of this atmospheric heat flow on Earth is from the tropics toward the poles. Coriolis forces (produced by planetary rotation) cause the descending gas, which would normally move north or south, to flow around the planet west to east. However on Earth, unstable flow converts this west-east motion into the enormous spirals known as cyclones and anticyclones. These systems in turn generally move from west to east.

Because of instabilities like those on Earth, weather flow on Jupiter should be in even more violent spirals than Earth's. But several factors appear to have a "calming effect", so that the motion is mostly linear. These factors include Jupiter's internal heat source and heat circulation, lack of a solid surface and the general liquid character of the huge planet. As a result, the combination of convection due to the sun's heat plus internal heat, and coriolis due to Jupiter's 22,000 m.p.h. rotation, stretches the planet's large permanent weather features completely around the planet forming the belts and zones. One "calming effect" in Jupiter's weather is that heat radiated from Jupiter's center reaches all parts of the planet's surface in equal amounts. By contrast, Earth's heat from the sun is received mostly in the tropics and circulates toward the icy poles.

The gray-white zones are warm, upward rising "stretched" weather cells, whose tops are high clouds of ammonia crystals. The lower red-brown areas are descending weather cells, believed to be clouds of mainly ammonia hydrosulphide crystals.

The tops of the bands of lightweight, upward rising white clouds flow from the center to the edges. Cloud material in the heavier dark belts funnels downward from the edges to the center of the belts. Because of the tremendous forces of planetary rotation each belt or zone tends to have its own velocity. This means that Jupiter's various bands are jet streams of atmosphere whose speeds of flow can differ by as much as 360 m.h.p. Continent sized eddies, created when one stream has a high velocity relative to another, are clearly visible in the detailed Pioneer pictures of the planet. In general, these atmosphere streams flow most rapidly near the equator while the greatest contrasts in flow speeds occur at mid-latitudes.

High activity of Jupiter's atmospheric circulation is further shown by ultraviolet measurements of atomic versus molecular hydrogen according to Darrell Judge of the University of Southern California. This ratio shows that the atmospheric mixing rate in the top of the atmosphere is 10 to 100 times as high as in the top of Earth's atmosphere.

Jupiter's most famous feature, the Great Red Spot, appears to be a centuries old, 25,000 mile wide vortex of a violent storm, as first proposed by the late Gerard P. Kuiper. The spot is calculated to rise some five miles above the surrounding cloud deck. This was determined by the fact that the clouds at the top of the spot have less atmosphere above them and are cooler (and hence higher) than surrounding clouds.

Jupiter's liquid character and the fact that the spot was not "seen" by the gravity-sensing experiment (which should have seen even small variations in density) seem to eliminate most previous theories on the nature of the mystery. Pioneer 10 pictures show that the spot's internal structure appears to be a pinwheellike vortex and that its rapid circulation pattern makes it rigid enough to displace the clouds of the south tropical zone. Somehow it seems to be continually "fed" from far below.

A second Red Spot, about 1/ 3 the size of the Great Red Spot, can be seen in the Pioneer picture on page 8 . It is located in the northern counterpart of the southern hemisphere zone containing the Great Red Spot. The Little Red Spot also is cooler than its surrounding clouds, and is believed to rise as high as the Great Red Spot. This second spot lends support to the idea that the Red Spots are occasional meteorological phenomena on Jupiter, found in the middle of the planet's bright zones where the atmosphere is rising.

All of the savage weather visible at the cloud tops and within the belts and zones of the giant planet are part of the atmosphere of Jupiter. Below the bright zones and belts, the exact structure of Jupiter's atmosphere is, naturally, less clearly known. Pioneer 10 data has shown that the region defined as the atmosphere of Jupiter is about 600 miles thick. The colorful clouds that we see from Earth are believed to be about 125 miles down from what is considered the top of the atmosphere. The deeper we go, the higher the temperature gets because of the internal heat of the planet and because of the greenhouse effect

(retention of the sun's heat by the gases of the atmosphere).

Not far below the clouds the temperature is high enough so that ammonia is no longer frozen and water ice (snowflakes?) is drifting around in the weather circulation along with ammonia droplets. Continuing farther down, the temperature and atmospheric pressure more rapidly increase. Water is abundant in the form of droplets containing ammonia in solution. It is here that past speculation of life on Jupiter has been focused. The Pioneer data neither confirmed nor denied the existence of some form of airborne life that might float in the atmosphere at this level. Just what the weather is in these lower cloud layers is unknown — aside from the up-down circulation of the atmosphere. There may be lightning and violent storm activity but the conditions here are still largely unknown and consequently this is a prime region for exploration by an atmospheric probe.

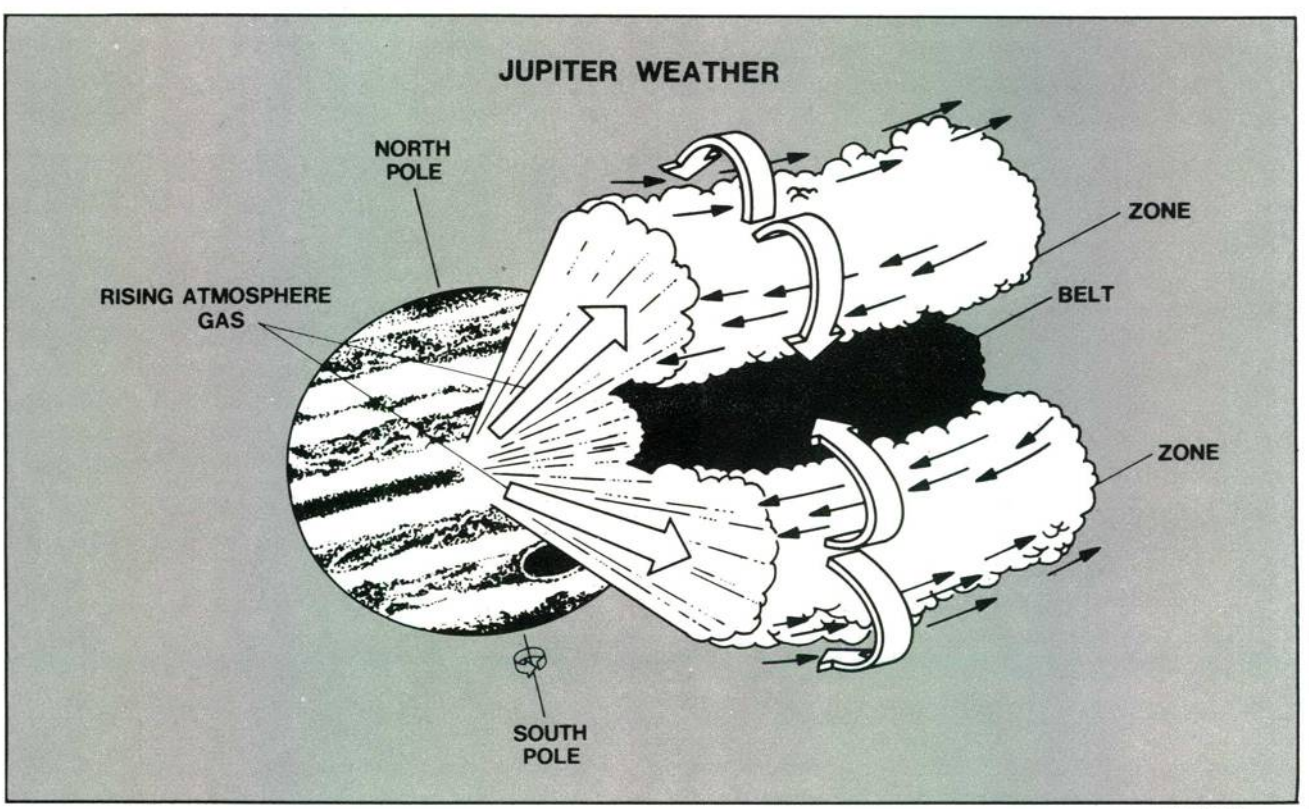
About 600 miles from the topmost levels of the atmosphere a strange transition takes place. The atmospheric pressure increases rapidly and the sky becomes totally dark. Pressures here produce such densities that the helium and hydrogen are compressed to what we would consider a liquid. The 3,600 degree temperature here makes this a bizarre environment.

Going still deeper, at 1,800 miles down the temperature is 10,000 degrees and the pressure is 90,000 times the atmospheric pressure on the surface of Earth. At this point the weight of the Jovian atmosphere has compressed the hydrogen gradually into the form of a liquid about 1/ 4 as dense as water. At 15,000 miles down (about 1/ 3 of the way to the core), the temperature reaches 20,000 degrees and the pressure is 3,000,000 atmospheres. At this level, liquid hydrogen turns to liquid metallic hydrogen.

From this new portrait of Jupiter it's obvious that the big planet is truly an alien body, totally unlike Earth. Indeed, in some ways it is more like a star than a planet.

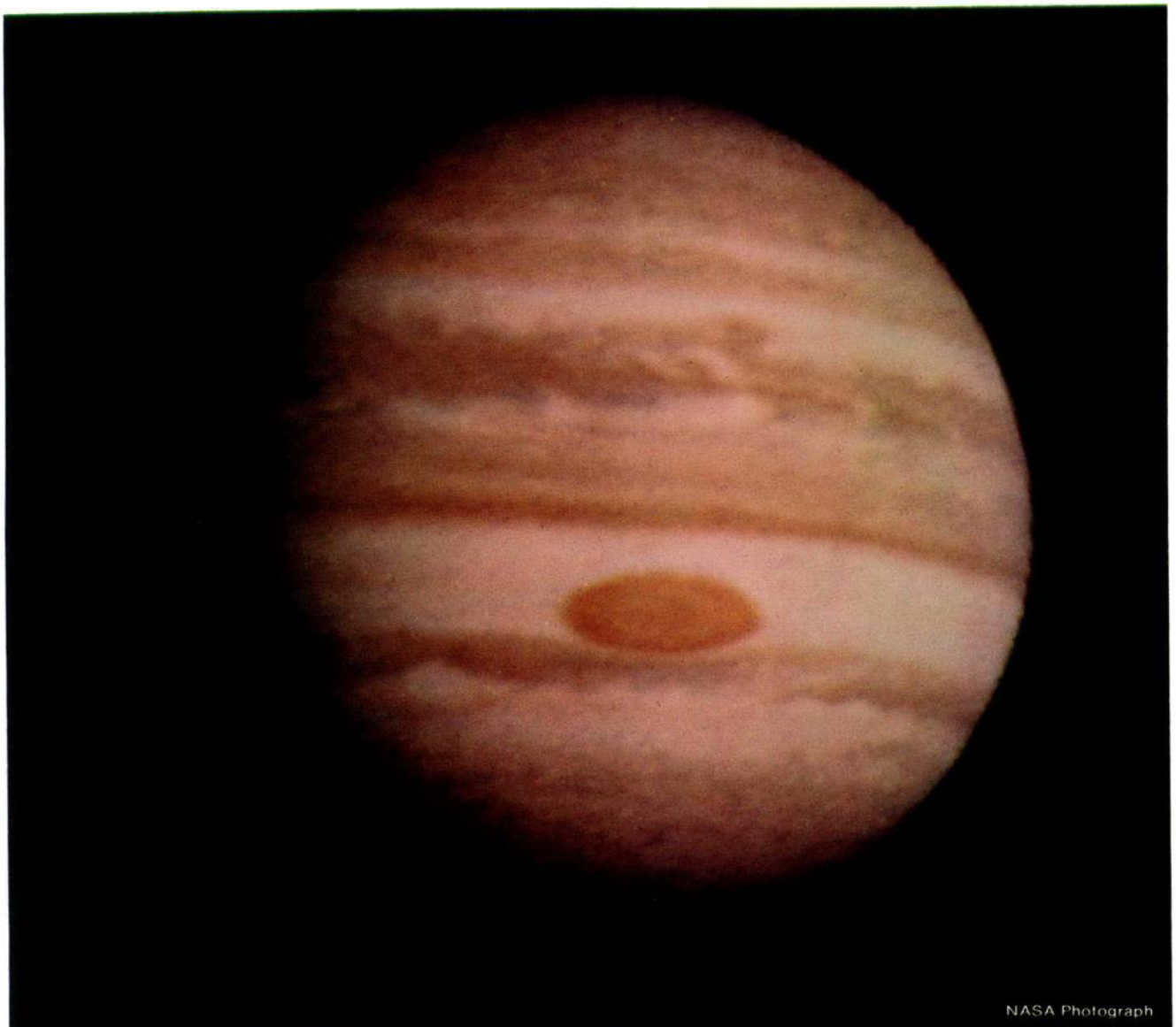
Deep inside Jupiter, near the core, incredible pressures are concentrated on a region where the temperature is 54,000 degrees — six times hotter than the surface of the sun. Yet this is still a long way from the several million degrees required to ignite the nuclear "fires" that power stars. Jupiter is a star that failed.

As we have seen, from the center outward



NASA Diagram

The general circulation in the upper regions of Jupiter's atmosphere is east-west, superimposed on a welling up and sinking. The white ammonia clouds of the zones loom eight miles above the darker brown-orange clouds of the belts. This circulation pattern is stabilized by Jupiter's rapid rotation and high internal heat. Wind velocities in the belts and zones can differ by 350 m.p.h.



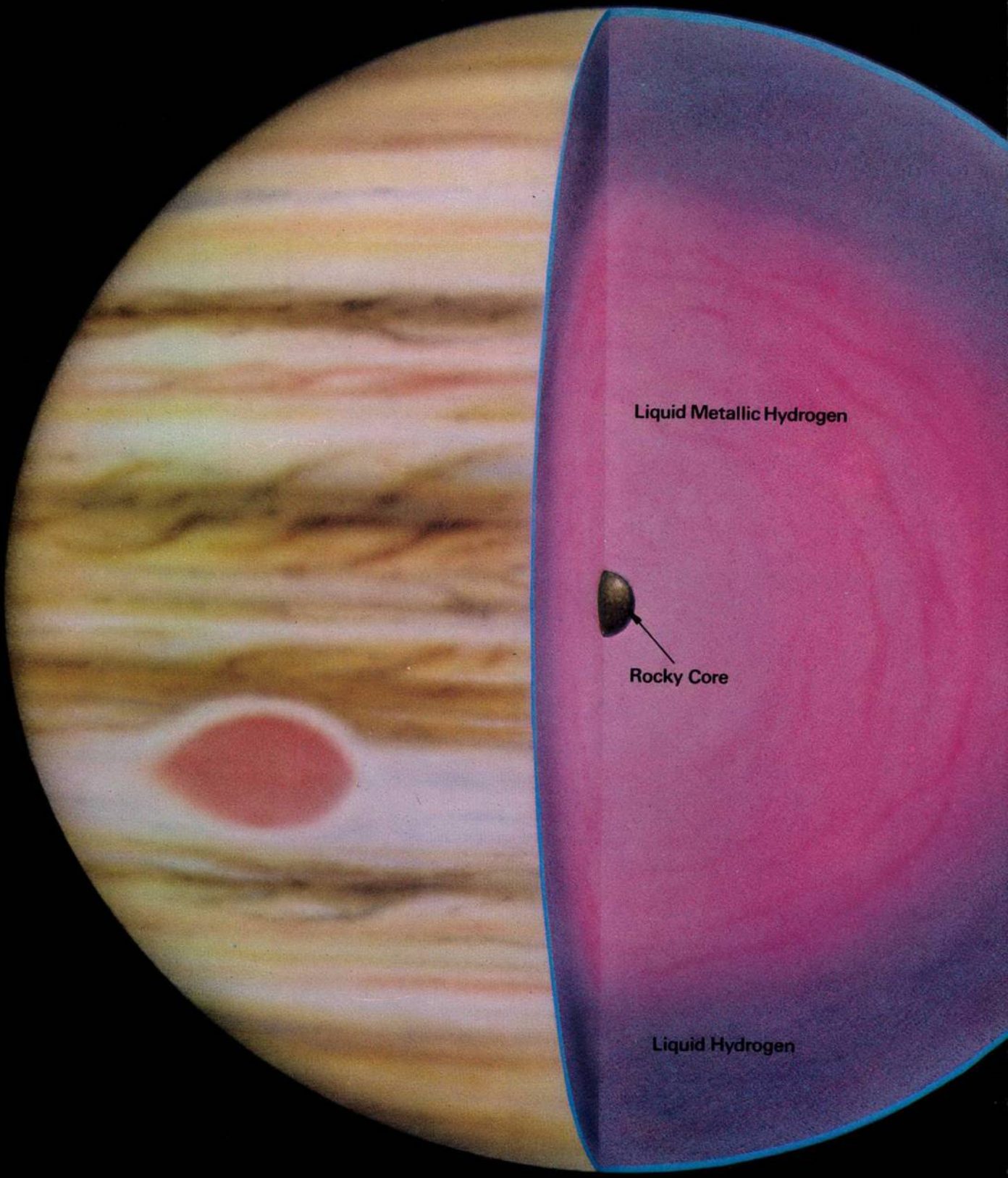
NASA Photograph

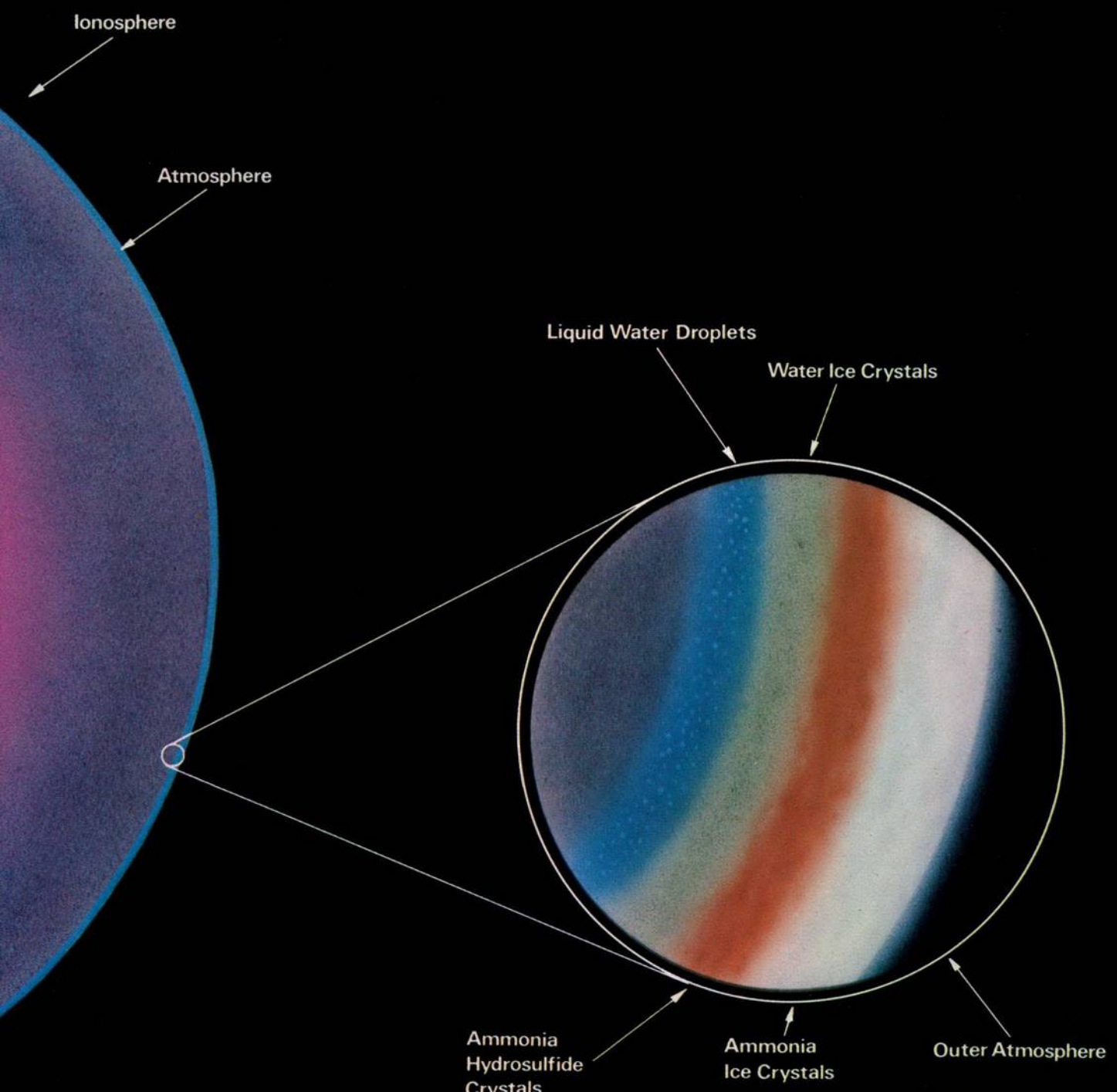
The frosty clouds that top Jupiter's atmosphere are spun into streaming bands by the planet's rapid rotation and internal heat. Wider than three Earths, the Great Red Spot puzzled astronomers for decades but is now known to be a titanic storm system that rises five miles above the surrounding vista of pale ammonia clouds. This photo was taken in Dec. 1973 while Pioneer 10 was 1,840,000 miles from Jupiter.

the temperature decreases steadily to the frigid cloud tops at the "surface". Jupiter's hot interior is believed to literally seethe as convective currents circle and eddy, carrying the heat to the surface.

William B. Hubbard of the University of Arizona estimates that hydrogen moving up from Jupiter's center covers the 44,000 miles from the center of the planet to the top of the atmosphere in 10 to 100 years. Interior currents move as fast as 1,500 miles per year, he estimates. The rapid convection of heat is reflected in the constant rise and fall of the atmosphere. This is shown by a number of prominent, semipermanent features seen in the planet's clouds — such as striking white ovals of rising atmosphere surrounded by darker borders of descending atmosphere.

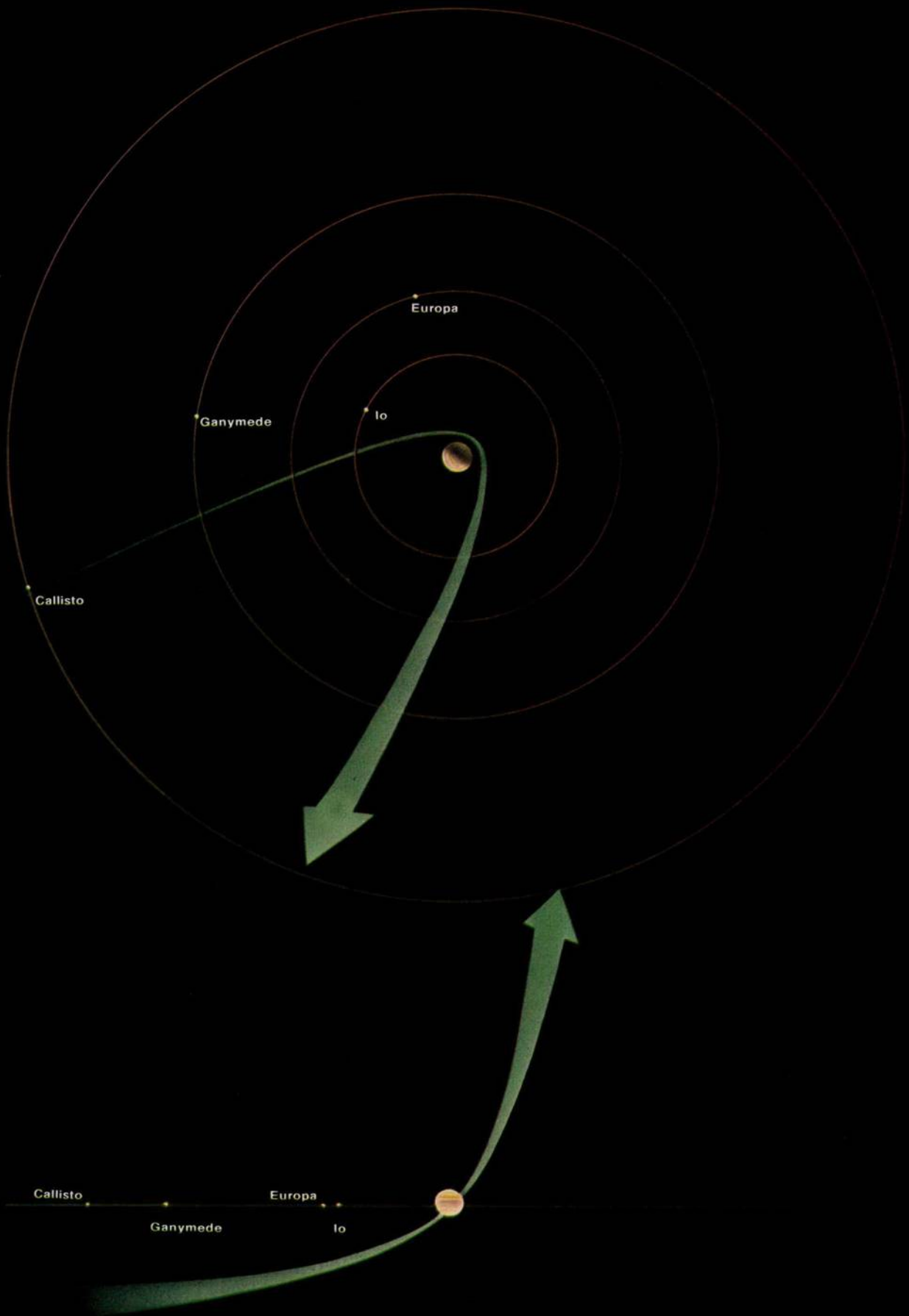
The best explanation for Jupiter's tremendous internal heat is that it is primordial heat left over from the heat of formation of the planet at the time the solar system was formed. The central temperature could have been maintained to the present by a slow contraction of the planet amounting to a shrinkage of only one millimeter per year. The high heat of formation is confirmed by Pioneer measurements of the closest large moons — Io and Europa — which, unlike the two planet sized "ice" moons lying farther out, are rocky. James Pollack of NASA's Ames Research Center believes that a hot primordial Jupiter


Liquid Metallic Hydrogen
Rocky Core
Liquid Hydrogen



Refinement of information received from Pioneer 10 has resulted in this model of the interior of Jupiter. The small rocky core may not exist and future analysis should reveal its dimensions if it does. Jupiter's atmosphere looks thin but is actually 600 miles deep and consists of a "sandwich" as shown in the close-up view. Below the atmosphere, the liquid hydrogen zone is about 15,000 miles thick. From pole to pole the huge planet is 82,960 miles in diameter — 10 times the size of Earth. With a central temperature of 54,000 degrees and a largely hydrogen composition, Jupiter is more like the sun than Earth. If Jupiter were 80 times more massive it would be a star. Artwork by Victor Costanzo

Pioneer 11 Swings by Jupiter



radiated enough heat to prevent water vapor from condensing into ice during formation of Io and Europa. (An alternative explanation by some scientists for part of Jupiter's internal heat is that it is energy released by the fractionation of hydrogen and helium — a process believed to be currently underway somewhere near the center of the planet.)

Pioneer 10 found that the strength of Jupiter's magnetic field at the planet's cloud tops is more than 10 times the strength of Earth's field at Earth's surface. Total energy in the Jovian field is 400 million times that of Earth's. Jupiter's inner magnetic field extends into space in a doughnut shaped ring about 800,000 miles from the planet's cloud tops. The outer field extends in a flatter ring to a minimum distance of 2.1 million miles from Jupiter's cloud tops, and sometimes reaches out three times as far. The poles of Jupiter's field are reversed from Earth's; a Jovian compass would point south.

Jupiter's inner field is tilted about 10 degrees to the planet's axis of rotation, and the center of the field lies about 1,320 miles north of the center of the planet and 4,840 miles outward from the rotational axis in a direction parallel with the equator.

Because the field's center is not in the center of the planet, the strength of the field as it emerges from the cloud tops is calculated to vary over the clouds' surface from 3 to 10 Gauss. At its closest approach, 81,000 miles above the cloud tops, Pioneer 10 measured a field strength of 0.2 Gauss. (Earth's field at the surface is 0.35 Gauss.) Because Jupiter's magnetic field is tilted 10 degrees to the planet's axis of rotation, the inner field (as seen from space) wobbles up and down through an arc of 20 degrees once every 10 hour rotation of Jupiter.

The displacement of the center of Jupiter's magnetic field from the center of the planet, and tilt of the field, further confirm that Jupiter is a huge, flattened, fast-spinning ball of liquid hydrogen. Jupiter's field like Earth's is believed to result from a "dynamo effect" within the planet, in which eddies (circular currents) within the liquid interior generate electric currents, and hence magnetic fields. Only a planet with a tremendously active interior, scientists believe, could produce a magnetic field as far offset from its center as Jupiter's.

As on Earth, the high energy particles which form Jupiter's inner radiation belt are trapped within the planet's inner magnetic field. In the weak outer magnetic field, particles bounce around but eventually make their way to the field's outer edge. There they are spun off into space by the high speed rotation of the planet and by the radiation belts themselves.

Jupiter's radiation belts have the highest intensity ever observed by space measurements, according to James Van Allen of the University of Iowa. The maximum radiation measured by Pioneer 10 was about 100 times the lethal dose for humans, and was near the limit of radiation tolerance for spacecraft systems. The belts' intense particle radiation pose the greatest threat to spacecraft flying close to Jupiter, or orbiting the planet. Three of the four planet sized moons lie within the intense inner radiation belt. Hence a manned landing on one of them would be impossible without very advanced technology to protect the men. The fourth big moon, Callisto, lies outside the region of intense radiation, and would be somewhat more feasible for a manned landing.

In general, the most dangerous part of Jupiter's radiation zone is in the planet's equatorial plane. Even though Pioneer 11 will zoom in three times closer than its predecessor on Dec. 3, it won't stay long in the equatorial region. The spacecraft's path will carry it in a looping trajectory that swings up from the south polar region through the equatorial zone, and back out over the north pole on its way to a rendezvous with Saturn in 1979.

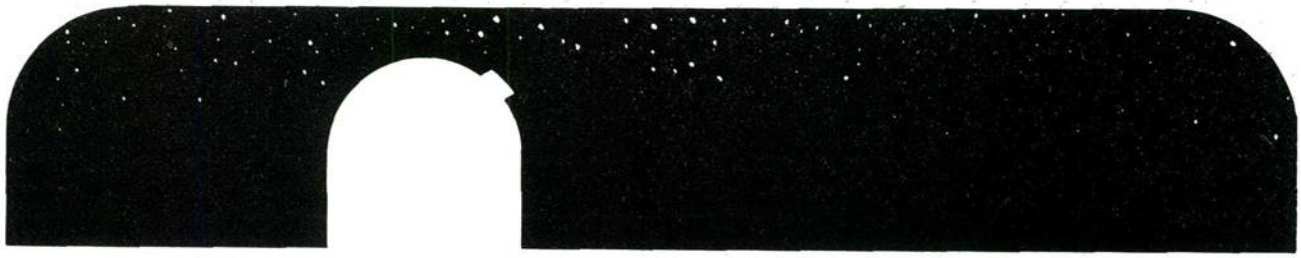
Pioneer 10's visit to the titanic planet provided the first firm ideas of what Jupiter is really like. Now, Pioneer 11 is ready to add to the legacy of the first flight to Jupiter. Although less dramatic, this second mission may reveal new and startling information about a strange and alien world that will not be thoroughly understood for centuries.

For more information about Jupiter and the Pioneer missions, consult these articles in recent issues of ASTRONOMY: "Jupiter To Have Its Temperature Taken" and "Scientific Opinion Divided About Life on Jupiter", December 1973; "Encounter With Jupiter", February 1974; "Jupiter", April 1974; "The Forbidden Moons" and "Pioneer 11 to Visit Saturn", May 1974; "Planetary Bonanza", June 1974.

An excellent introduction to the giant planet is **Jupiter — The Largest Planet** by Isaac Asimov (Lothrop, Lee, & Shepard Co., 1973).

On Dec. 3, 1974, Pioneer 11 will hurtle to within 29,000 miles of Jupiter. These two views show the spacecraft's path as seen from above Jupiter's north pole and from the plane of its equator. Pioneer is targeted to come under Jupiter and its moons, sweep behind the planet and exit from above. The four large moons appear where they will be at time of closest approach. The edge-on view of the system approximates the appearance from Earth.

Artwork by Victor Costanzo



PUBLISHER'S MEMO

We've got miles of territory to cover this month. So without pomp and ceremony, we're off....

First, I would like to personally welcome about 10,000 new subscribers to ASTRONOMY magazine. In this age of so many advertising rip-offs, I assure you, new subscribers and old, that we will faithfully live up to the quality and excellence promised in our direct mail campaign. For the information of our new subscribers, we're already making plans to go "one better" than what we promised in our promotional brochure: Starting with the January 1975 issue, ASTRONOMY will assume a base size of 80 pages and add Equipment Atlas as a regular monthly department. To this end we're looking for a qualified assistant editor. Starting with last month's issue (October) we improved ASTRONOMY'S cover by adding a glossy, protective varnish coating. So, all you new subscribers stay tuned to this magazine — cause you'll eventually get more than you bargained for!

The other day your mighty publisher was rummaging through ASTRONOMY'S inventory of back issues and holy gobs of joyful grief he found the cupboard was getting mighty lean! By the time you read this memo the status of our back issues will be as follows:

Issue Month	Volume	Status
August 1973	Vol. 1, No. 1	Lots 'n' lots
September 1973	Vol. 1, No. 2	Gettin' low
* October 1973	Vol. 1, No. 3	Ain't none
* November 1973	Vol. 1, No. 4	Same here
* December 1973	Vol. 1, No. 5	Ditto
* January 1974	Vol. 2, No. 1	R.I.P.
* February 1974	Vol. 2, No. 2	A'w gone
March 1974	Vol. 2, No. 3	Simply gobs of 'em
April 1974	Vol. 2, No. 4	Hangin' in there
May 1974	Vol. 2, No. 5	More than a few
* June 1974	Vol. 2, No. 6	Ain't no more
July 1974	Vol. 2, No. 7	Literally gobs
* August 1974	Vol. 2, No. 8	R.I.P. ditto
September 1974	Vol. 2, No. 9	Mucho
October 1974	Vol. 2, No. 10	Gobs 'n' more gobs

Those of you who don't appreciate the creative nonsense under the status column should refer to the asterisk next to the months in which back issues are no longer available. All available back issues cost $1.50 per copy including postage. Payment should be sent with your order. In the event you request a back issue which is sold out, we will automatically send you a refund for the missing issues.

Astro-Mart is really catching on! Not only with paid commercial advertisers but among our subscribers as well. As a result we're getting pleasantly backlogged with free ads. So in order to print more subscriber ads in each issue of ASTRONOMY, we've reduced the type size. If you send in an ad and don't see it right away, just be patient — it will be used as soon as possible. Since free Astro-Mart classifieds are published on a first come, first served basis, we cannot guarantee insertion in any specific issue.

As more paid commercial advertisers appear in Astro-Mart, we will be able to expand the number of pages devoted to this department and can include more free subscriber classifieds.

You will notice as you delve further into this issue that Gazer's Gazette and Stellar Frontiers are missing. Well, it seems astronomers are finally getting the real lowdown on the planet Jupiter. Like, for instance, it doesn't have a solid surface — anywhere! It's just a frustrated star that never was — a confused planet that never will be. Should we call this crossbreed a "slanet" or maybe just a "pun", by jove?! Anyway, it makes for interesting reading, so we gave it a few more pages than we normally give our lead articles. Also, more goodies have been happening in the newsy world of astronomy lately so Astro-News is fatter. Never fear, friends, the prodigal departments will find their way home next issue.

Speaking of December, that brings to mind January and fond thoughts of 1975. To celebrate its arrival — 1975 that is — we borrowed a chunk of the constellation Sagittarius (the Trifid nebula, to be exact) and created our 1975 poster calendar. We think you will find this 22 x 34 inch marvel as colorful, exciting and beautiful as our 1974 Orion Calendar. The price is $3.75 each and they will be rolled and shipped in mailing tubes. Because of the postal delivery problems we have encountered — delays and destroyed calendars — we are asking for 25¢ more than last year so we can ship calendars via first class mail. While the price is higher, we actually will make less on the

1975 calendar than on last year's because of inflation. Our first shipment will be made Nov. 25. If you plan to give the 1975 Trifid Calendar as a Christmas gift, place your order immediately so it will arrive in time for Christmas. Of course, we still offer the lithographs of Mars as Seen From Deimos and the Milky Way in Sagittarius. See our ad on page 29.

Almost since our first issue (August 1973), we've received many requests from our readers for reprints of artwork and photographs that have appeared in ASTRONOMY. Naturally, we wish to satisfy everyone, but the time has come for us to really find out exactly what you'd like to buy. The more people who want a particular item at a given price, the more reasonable and economical it becomes to produce.

So here are a few questions I'd like you to answer. Let me know what you want. Either circle your answers below and send in this page or write them out in a personal letter to me.

1) Which would you like to see reproduced?
2) In what size and at what price would you buy?

Item	Size (Inches)	(Circle the price you would be willing to pay.)		
Color Paintings & Artwork	8-1/2 x 11	$1.00	$1.50	$2.00
	11 x 17	1.75	2.25	2.75
	17 x 22	2.50	3.00	3.50
	22 x 34	3.75	4.25	4.75
Color Photographs	8-1/2 x 11	$1.00	$1.50	$2.00
	11 x 17	1.75	2.25	2.75
	17 x 22	2.50	3.00	3.50
	22 x 34	3.75	4.25	4.75
Black & White Photographs	8-1/2 x 11 (set of 8)	1.25 (per set)	1.75 (per set)	2.25 (per set)
	11 x 17 (set of 4)	1.75 (per set)	2.25 (per set)	2.75 (per set)
	17 x 22 (1 only)	2.00 (each)	2.50 (each)	3.00 (each)
	22 x 34 (1 only)	2.75 (each)	3.25 (each)	3.75 (each)

This memo is turning into a book, but one final point before your publisher throws in the towel: Your response to our requests for black and white and color photographs has been excellent. But for some reason we haven't received as many Perseid meteor shower photos as we had hoped for. How about it? For those we use in ASTRONOMY we pay $7.50 each for black and white and $10 for color. So why not send us your best of any celestial object — and don't overlook those excellent black and white photographs just because we use a lot of color.

Sincerely,

Stephen A. Walther

Stephen A. Walther
Publisher

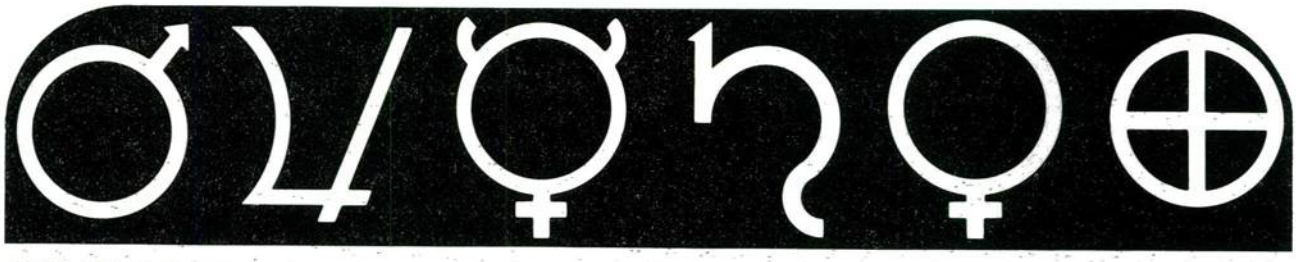
POSITION AVAILABLE
ASSISTANT EDITOR

ASTRONOMY magazine has an immediate opening for a Milwaukee based editorial staff member.

Journalism degree or journalism/science/astronomy course work in addition to practical editorial experience required; proven ability to write a necessity. Individual must be willing to relocate. Minimum salary for qualified person $12,000 first year (to be adjusted upward based on ability and experience).

For a complete outline of job requirements and the form in which applications should be submitted, write:

Stephen A. Walther, Publisher
ASTRONOMY Magazine
757 N. Broadway, Suite 204
Milwaukee, WI 53202



SKY ALMANAC

Three Planets Illuminate November Nights

November nights are long and sometimes cold. But consider this: In mid-November, the nights are the same length as those in late January. So this month we get a "darkness bargain". Even early in November your telescope can be hauled out under a dark sky at 6:00 p.m. throughout much of the country. It works the other way too — the sun rises late, so you might want to take advantage of Mercury's brief morning appearance.

For evening observers Jupiter is in excellent position and Saturn makes the night scene before midnight. All times given in Sky Almanac this month are eastern standard times as we are assuming the nation will switch to standard time this winter.

Jupiter

This is the last of the prime months to observe the giant planet. Although it will be in the evening sky until February, its increasing distance from Earth combined with a worsening sky location nearer the western horizon makes November the last good opportunity to catch up on your Jupiter observing.

Jupiter will be approximately due south as darkness falls, but it is well above the southern horizon in the dim constellation Aquarius. Its position relative to the surrounding stars is shown on page 28. The planet is still brilliant, dropping only slightly in brightness from magnitude -2.2 to -2.0 during November. Jupiter remains by far the brightest object in the evening sky apart from the moon.

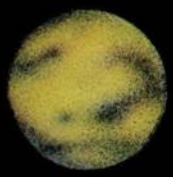
Through the telescope the big planet is particularly colorful this year with its Great Red Spot resembling the bloodshot eye of some science fiction movie monster. The vivid pink color of the spot contrasts beautifully with the white clouds that fill the weather belt it occupies (the south tropical zone). A further contrast is supplied by the dark rusty colored clouds of the equatorial belts. These distinctive features of the planet's weather pattern should all be visible in a telescope of three inches aperture or larger.

As the month begins, Jupiter is 410 million miles away and appears 44.6 seconds of arc in apparent equatorial diameter. By the end of November Earth will pull away to 452 million miles from the big planet — shrinking its apparent equatorial width to 38.0 seconds of arc. Because of Jupiter's rapid 10 hour rotation, the planet is compressed at the poles by about seven percent.

Watching the shadow of one of Jupiter's four large moons traverse the face of the colorful planet is among the top visual treats that astronomy offers. The tiny black dot inching its way across the quilt of Jovian clouds is a never ending fascination. This month is a rare opportunity to see two satellite shadows on the disk at the same time. On Nov. 13-14, according to the table on page 22, Ganymede's shadow will be projected on Jupiter from about 11:00 p.m. to 2:00 a.m. During the last 1-1/4 hours of that period, Europa's shadow will be there too. Around 1:15 a.m. on the morning of the 14th, both satellite shadows will be well placed on the disk of Jupiter — an ideal situation for comparison.

During this 30 minute exposure centered on the Andromeda galaxy, a Perseid meteor flashed across the camera's 135mm field of view. This unintentional "capture" combines a pinhead sized object only 100 miles away, stars hundreds of light-years distant and a galaxy of stars two million light-years from us. The photo was taken at f/4 on High Speed Ektachrome film.

Photograph by David A. Potter



Ⓒ Ceres

Nov.	1	15
R.A.	22h32m	22h36m
Dec.	-23°01'	-21°38'
Mag.	+7.6	+7.8

Ⓐ Mercury

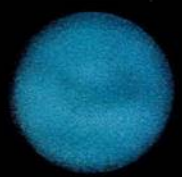
Nov.	1
R.A.	13h35m
Dec.	-8°27'
Mag.	+0.7

Ⓑ Mercury

Nov.	15
R.A.	14h15m
Dec.	-11°21'
Mag.	-0.5

Ⓜ Mars

Nov.	1	15
R.A.	14h04m	14h41m
Dec.	-12°12'	-15°24'
Mag.	+1.8	+1.8

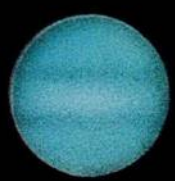


SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

Nov.	1	15
R.A.	7h22m	7h21m
Dec.	+21°38'	+21°41'
Mag.	+0.2	+0.1

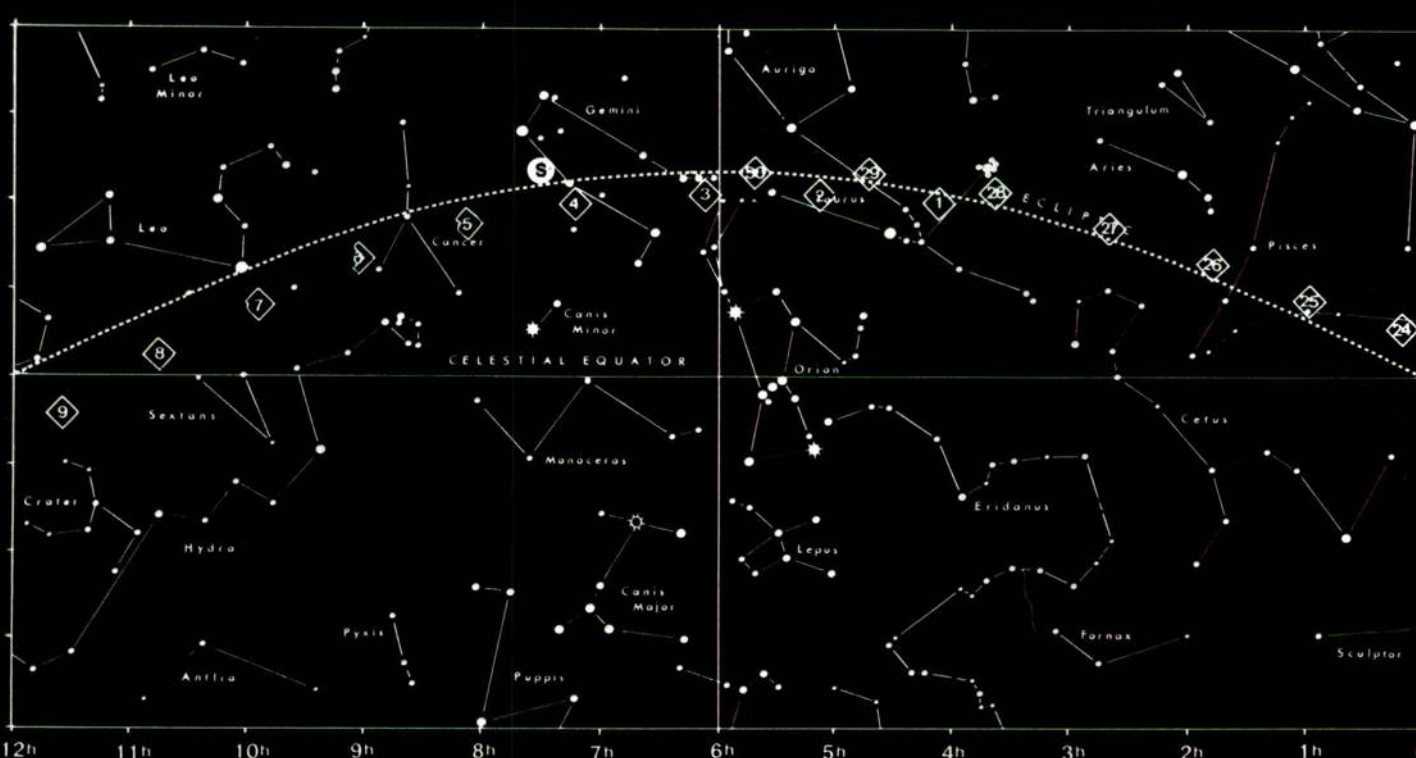


Ⓤ Uranus

Nov.	15
R.A.	13h51m
Dec.	-10°52'
Mag.	+5.8

Ⓝ Neptune

Nov.	15
R.A.	16h29m
Dec.	-20°15'
Mag.	+7.7



Map by Raymond G. Cousins

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a

(V) Vesta

Nov.	1	15
R.A.	16h19m	16h50m
Dec.	-19°13'	-20°42'
Mag.	+7.6	+7.7

(J) Jupiter

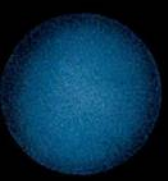
Nov.	1	15
R.A.	22h41m	22h41m
Dec.	-9°50'	-9°42'
Mag.	-2.2	-2.1

(Y) Venus

Nov.	1
R.A.	14h24m
Dec.	-13°19'
Mag.	-3.5

(Z) Venus

Nov.	15
R.A.	15h33m
Dec.	-18°44'
Mag.	-3.5



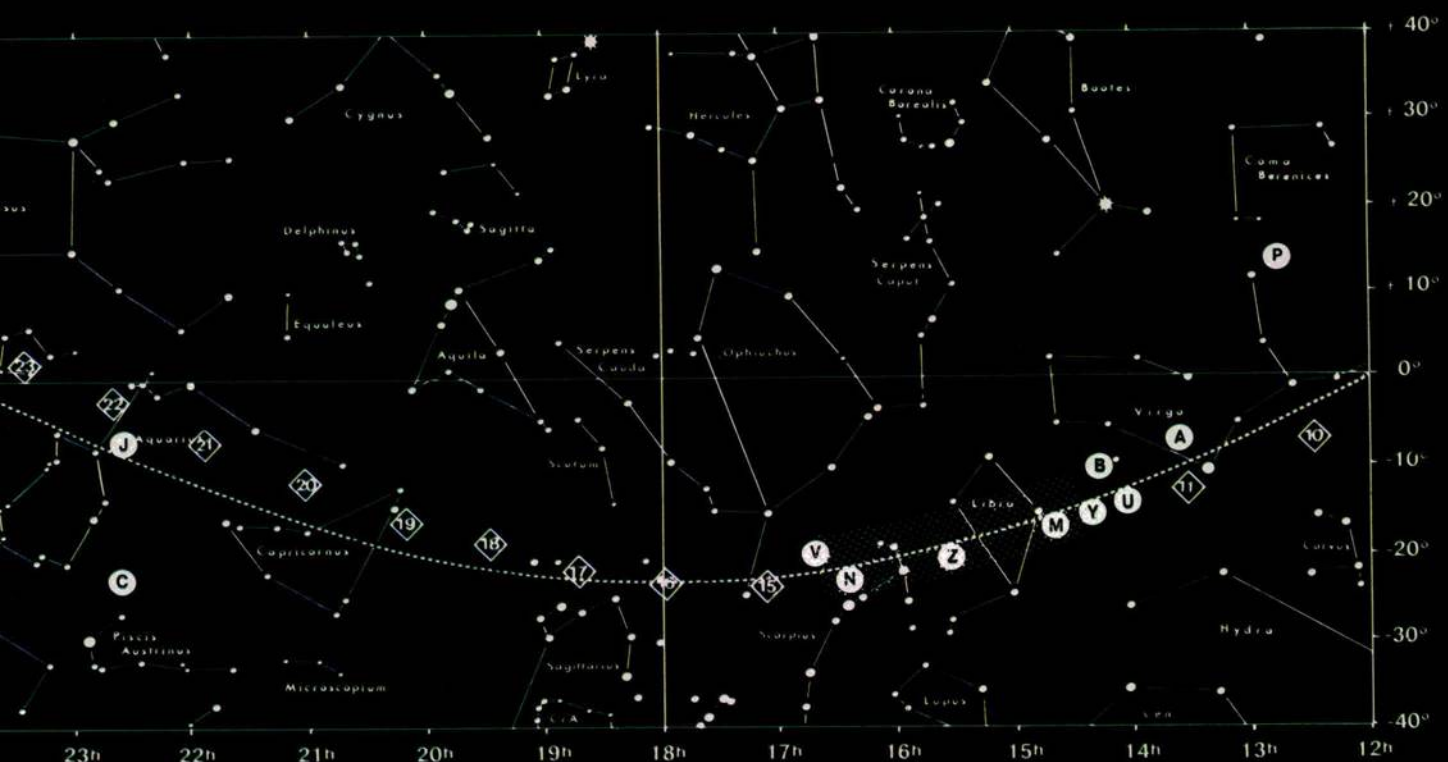
(P) Pluto

Nov.	15
R.A.	12h56m
Dec.	+11°51'
Mag.	+14.3

First Quarter
Nov. 21

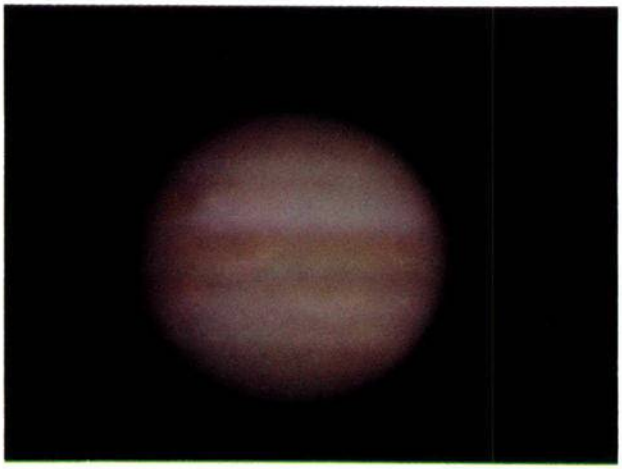
Full Moon
Nov. 29

Last Quarter
Nov. 6



Artwork by Victor Costanzo

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.



Photograph by Stephen C. Reed

The Great Red Spot peeks around the limb of Jupiter in this eight inch reflector telescope photo. Brownish equatorial belts loaded with fine detail are a contrast to the brilliant white south tropical zone — the horizontal band that the Red Spot never strays from. This 1-1/2 second exposure was taken at f/55 on Kodachrome-X, July 25, 1974.

Ganymede's shadow is larger than Europa's but is it much easier to see or are they both about the same?

At 1:15 a.m. Jupiter will be low in the west for observers in the eastern half of North America. However West Coast observers will have better viewing conditions since the planet will be higher in the sky (10:15 p.m. PST).

You may want to also note Callisto's shadow transit on Nov. 1. It's the last easily visible shadow event for that moon for many months.

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins (EST)	Transit ends (EST)
Nov. 1	4	5:52 p.m.	8:57 p.m.
5	3	6:46 p.m.	10:03 p.m.
5-6	2	10:09 p.m.	12:54 a.m.
6	1	9:04 p.m.	11:20 p.m.
12-13	3	10:49 p.m.	2:05 a.m.
13	2	12:45 a.m.	3:29 a.m.
13-14	1	11:00 p.m.	1:16 a.m.
15	1	5:29 p.m.	7:45 p.m.
22	1	7:25 p.m.	9:41 p.m.
23	2	4:39 p.m.	7:23 p.m.
29	1	9:22 p.m.	11:37 p.m.
30	2	7:15 p.m.	9:59 p.m.
Dec. 1	1	3:51 p.m.	6:06 p.m.

1 = Io 3 = Ganymede
2 = Europa 4 = Callisto

Saturn

The Saturn watching season is now underway. The bright yellow planet is prominent in the east after midnight at the beginning of the month, or after 10:00 p.m. by Dec. 1. Although a 2.4 inch refractor will show the rings, larger telescopes give splendid views of the main gap in the rings, called Cassini's division, and the pale orange bands that are a weak version of Jupiter's atmospheric kaleidoscope.

Finding Saturn is a little more difficult than locating Jupiter since the ringed planet is only 12 percent as bright. But Saturn is still zero magnitude. Look for it near the middle of the constellation Gemini. Saturn's prominence is somewhat diminished because it is in among the bright winter constellations, however the star Capella, farther north, is the only thing you are likely to confuse with Saturn.

Earth and Saturn are closing in toward a January rendezvous when they will be 747 million miles apart. On Nov. 1 Saturn is 804 million miles away, but by the 30th the gap closes to 766 million. The decrease in distance increases the planet's apparent brightness from magnitude +0.2 to 0.0.

The disk of Saturn in a telescope is noticeably larger than earlier this year. On the 1st the planet is 19.2 seconds of arc in apparent equatorial diameter while the rings appear to be 43.4 seconds wide. Those two dimensions increase to 20.2 and 45.5 seconds by Nov. 30.

Saturn's oddball moon Iapetus (pronounced eye-YAP-petus) is discussed in a major article in Astro-News this issue. If you want to find it yourself and watch its crazy light variations, look 12 full ring diameters west of Saturn around the 26th of this month. (West is to the left when the planet is oriented like the illustration on page 20.) Plot the positions of the stars, including the one you expect is the satellite, and in a night or two you will see the movement of Iapetus. It is magnitude 10.2 when west of Saturn and drops, for unknown reasons, to magnitude 11.9 when it reaches its greatest distance east of Saturn, 40 days later.

Saturn's bright giant moon Titan is about five ring diameters west of the planet on the 3rd and the 19th, and makes one orbit between these dates. At magnitude 8.4 it is easy to locate and follow from night to night.

Mercury

Zipping from one side of the sun to the other in just a few weeks is the routine of the sun's

nearest planet. The problem is that Mercury's tight little orbit seldom allows the planet to be away from the sun's glare (from our vantage point).

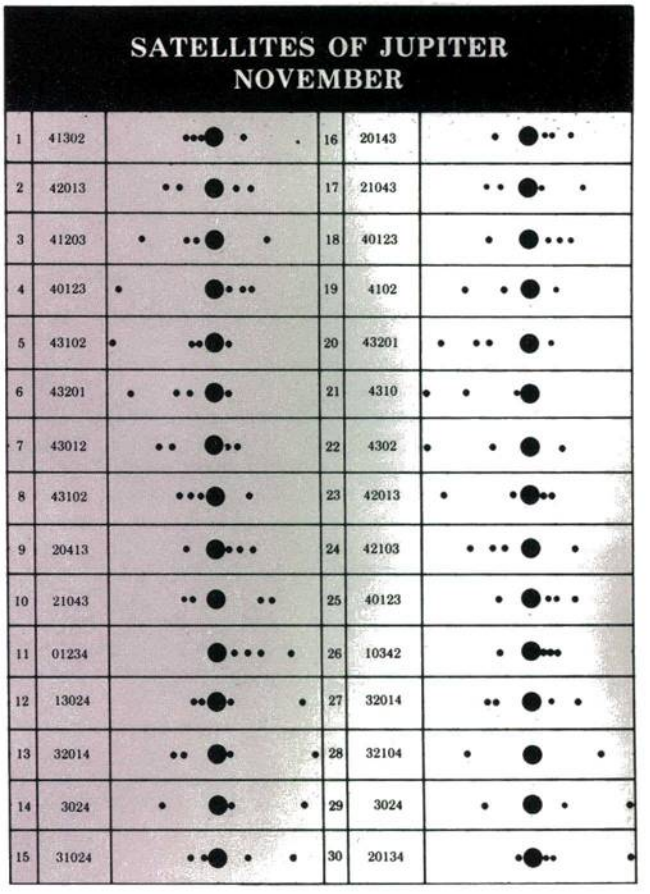
A fairly good opportunity to identify Mercury low in the east before sunrise comes early in the month from about the 4th to the 18th. During the first half of this period Mercury will be conveniently near Spica, making identification easier. On the morning of the 4th, Mercury will be about three degrees to the left of Spica and only slightly brighter (magnitude +0.5 compared to Spica's +0.9). A color comparison between the two might be interesting. Spica should look whiter than Mercury's usual yellow-orange hue. A general orange overtone affects all objects near the horizon (the orange setting sun for example) so the comparisons will be tipped in that direction.

Mercury moves slowly away from Spica and toward the horizon until it is 15 degrees from the star by the 18th. It's getting brighter all the time though, rising to -0.2 on the 9th and -0.6 from the 15th to the 18th. This brightness corresponds to a phase change — we see more of the planet's daytime side later in this observing period. Specifically Mercury will be a 29 percent illuminated crescent, 8.1 seconds of arc in diameter, on the morning of the 4th. The planet is a half illuminated 7.0 second sphere on the 9th and continues to shrink to a 5.7 second 80 percent gibbous phase by the 18th. A four inch or larger scope should reveal the phases although atmospheric turbulence often destroys the horizon-plagued Mercury observer.

Watch for the planet (and Spica) about 50 minutes before sunrise just south of the east

Photograph by James K. Rouse

Forty minutes after midnight on August 18-19, 1974, the Great Red Spot and the shadow of Jupiter's largest moon, Ganymede, shared the south tropical zone of the giant planet. Ganymede's shadow has been regularly traversing this zone recently — the wide, white region making a perfect backdrop for easy recognition. This photo was a five second exposure through an eight inch Newtonian reflector. The Kodak SO-410 film was developed for six minutes at 80 degrees Fahrenheit with H.C.-110 developer (dilution "D"). Atmospheric transparency and seeing were both excellent at the time of exposure. (All planet photos in this department have south at the top to duplicate the image orientation in most astronomical telescopes.)



The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 8 p.m. (EST) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto, and 0 = Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

Photograph by Scott Patterson

A Perseid meteor, brighter than Venus, swept through Andromeda on Aug. 11, 1974. Observing from northern Maine, the photographer used Tri-X film (processed to ASA 800) and a Spotmatic II camera with a 55mm lens at f/1.8. This spectacular meteor left a trail that lasted for 30 seconds. From several hundred miles away this meteor would have been too near the horizon to have been easily observed.

point. Once your telescope is on it, don't lose it because the sky will be brightening fast as sunrise approaches. Keep watching right into daylight — you'll be surprised how easy it is to telescopically observe Mercury in broad daylight.

Venus, Mars, Uranus, Neptune and Pluto

All these planets are on the other side of their orbits — thus placing the sun approximately between us and them. They will all be well placed for observation at various times in 1975.

Meteors

Two weak meteor showers are due to add a little "zip" now and then to the November night sky. The Taurid meteors, due on the 4th, will be virtually wiped out by the light of the gibbous moon.

Meanwhile the Leonids, expected to be very sparse this year, have no moonlight to contend with when they peak out on the morning of the 17th. Judging by past experience the Leonids will yield less than 1/ 2 dozen meteors per hour in the morning hours. Surprise bursts of activity are unlikely but you never can be certain. What meteors there are will seem to originate in the constellation Leo, which rises in the east about 1:00 a.m.

Miscellaneous

Our apologies are extended to those readers who were confused by our blunder in this department in the September 1974 issue. We incorrectly said that Jupiter was visible in the southwest evening sky instead of the southeast.

For those of you who enjoy seeing the photographic efforts of our contributors each month, why not have another look through your slide or print file? If you have any "goodies", send them to The Editors, ASTRONOMY, 757 N. Broadway, Suite 204, Milwaukee, Wisc. 53202. We pay $7.50 for black and white and $10 for color. For black and white photos, send prints only — no negatives please; for color slides, duplicates or originals are acceptable. Although we have never yet lost an original we can't be responsible in the rare instance that one may get misplaced or disappear in transit. Please print your name on each slide or print. They will be returned promptly if we don't plan to use them. If we feel we can use your photo we will have to keep it for at least a month and probably longer so be prepared to be without it for some time. We often have to reject photos because one or more of the following items are missing: date, time, subject, camera lens, length of exposure, film type. For some subjects all this information may not be necessary, but it is wise to include it anyway. Who knows? In the next issue we may use your photo. On page 34 we used one from 1966 — so search your photo files!

We've had the SUPERSTARS! Poul Anderson / Piers Anthony / Richard Ashby / Dr. Gregory Benford / Ray Bradbury / John Brunner / Ed Bryant / F.M. Busby / Terry Carr / Philip K. Dick / Scott Edelstein / Larry Eisenberg / Harlan Ellison / Roberto Fuentes / Stephen Goldin / James Gunn / Harry Harrison / Robert Heinlein / Frank Herbert / Walt Liebscher / George R. R. Martin / Larry Niven / Rachel Cosgrove Payes / Dr. Jerry Pournelle / William Rotsler / Joanna Russ / Neil Shapiro / Robert Silverberg / Norman Spinrad / James Sutherland / A. E. Van Vogt / and Ted White / **So guess who's coming next in VERTEX!**

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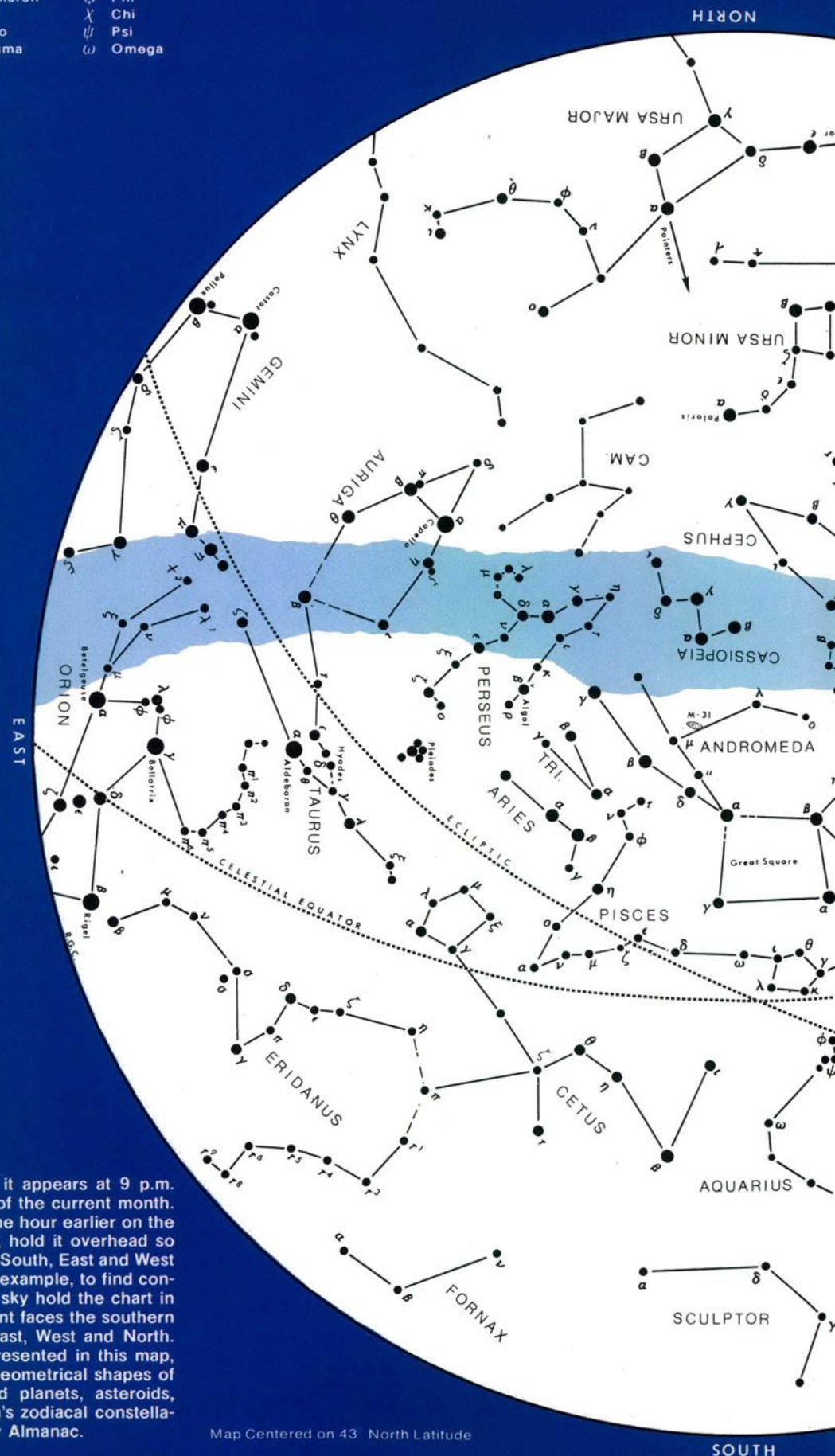
NOVEMBER

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet

α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	o	Omicron	ϕ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ϵ	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega



MAGNITUDES

- Zero
- First
- Second
- Third
- Fourth
- Fifth

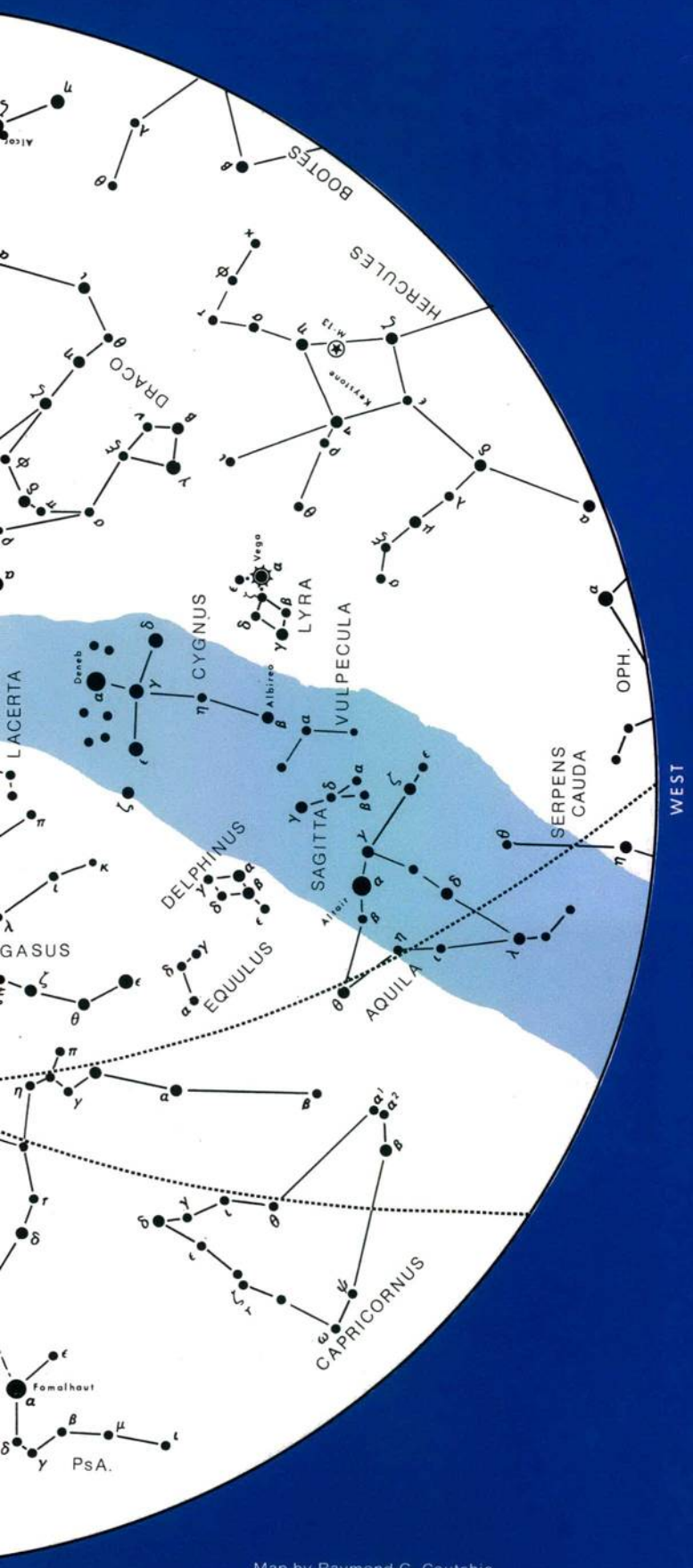
OBJECTS

- Open Clusters
- Globular Clusters
- Diffuse Nebulae
- Galaxies
- Double Stars
- Variable Stars

Star Dome approximates the sky as it appears at 9 p.m. Local Standard Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

Map Centered on 43° North Latitude

STAR DOME



Map by Raymond G. Coutchie

For several reasons, November seems to be one of the least popular times for sky gazing. The stars of the early evening this month seem fainter than those of any other time of the year. And this impression is correct. The autumn stars *are* fainter than those of any other season and consequently it's a little more difficult to find your way among them. We're also less inclined to explore the skies of a November evening because the weather is turning cooler.

Well, we've certainly started on a pessimistic tone! To reverse that we should emphasize that there are some very exciting things in the autumn sky that you can see with your unaided eyes or ordinary binoculars. Let's start by finding our way around the sky.

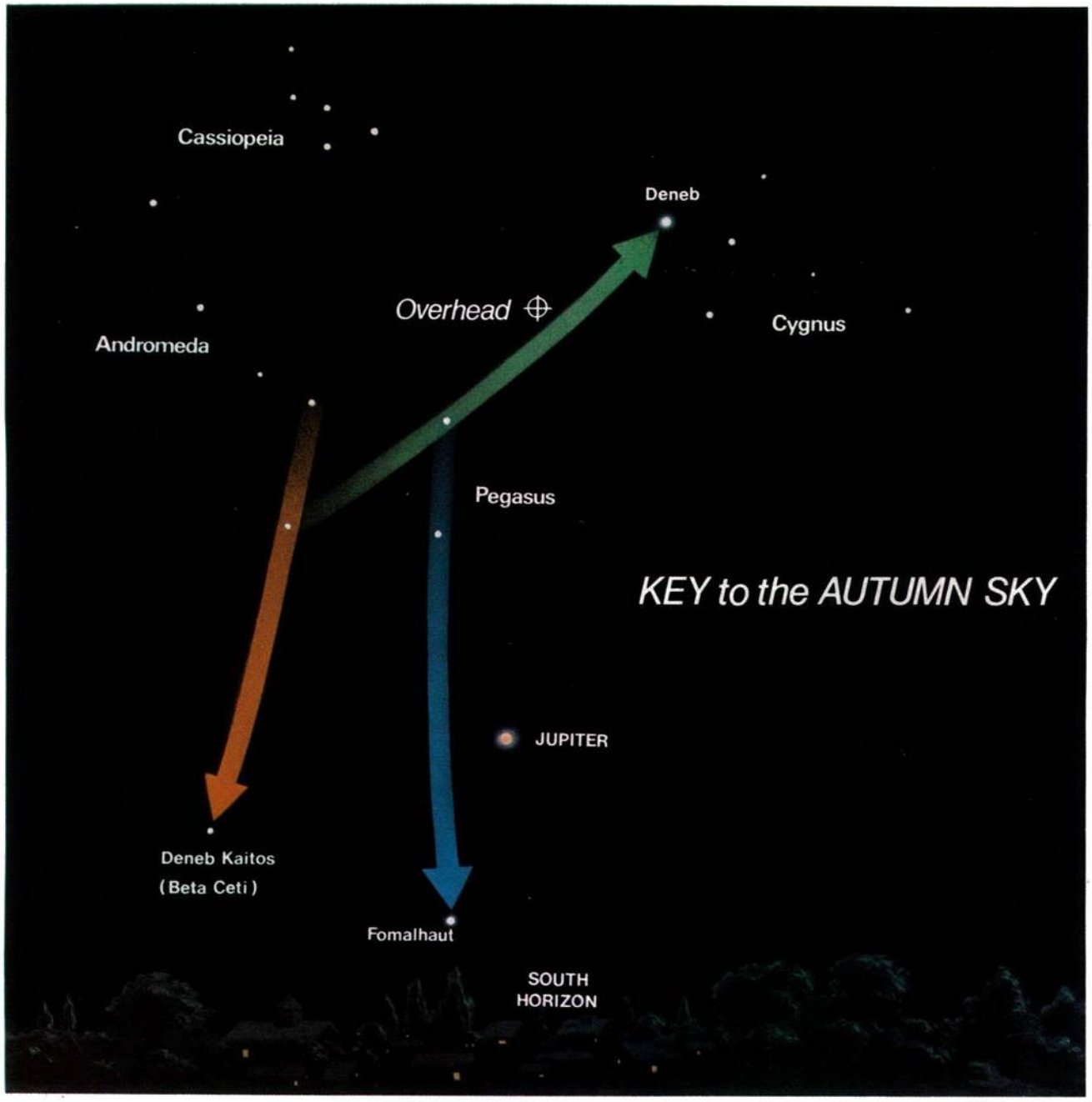
Our key is the Great Square of Pegasus — four second magnitude stars that form a nearly perfect square just south of the overhead point as soon as it gets dark on these November evenings. This year we can cheat a little bit in finding our way in the autumn sky by using Jupiter, by far the brightest object in the sky this month. Jupiter is now high in the south in the early evenings, directly between the first magnitude star Fomalhaut (FOE-mal-oat) and the west side (right side) of the Pegasus square. Our key map to the autumn sky shows it more clearly than we can describe it.

Fomalhaut is the brightest star in Pisces Austrinus (the southern fish) and is the only star of note in that otherwise dim constellation. Jupiter happens to be centered in the constellation Aquarius. Despite the fame brought to it by the popular song and its connection with astrology, Aquarius is definitely a loser as a constellation. Its brightest star is magnitude +2.9.

A key constellation this month is Andromeda which is conveniently attached directly to the northeast corner of the square. In fact, the star that attaches it — Alpha Andromedae — is not part of Pegasus at all. The Great Square is only an arbitrary collection of four bright stars that happen to form a convenient geometrical pattern useful as a guide to other stars.

We can use the Great Square to check the location of Deneb in the constellation Cygnus. Going from the lower left to the upper right corner of the square, we extend our gaze about three times the distance between those two stars and arrive at Deneb. A star with a similar name, Deneb Kaitos (Beta Ceti), can be located by dropping a line down from the two left stars of the square.

Most of the objects that we have been talking about are located on our key map on page 28



along with Cassiopeia, the constellation discussed in this month's Constellation Close-Up. Turning back to the main map on the previous pages we can identify a circle of stars directly under the square marking the western end of Pisces, another famous zodiac constellation. Like Aquarius, Pisces is not a dazzler.

Let's take out our binoculars and see what we can locate in this region. Just sweep around. First of all you'll find that what the eye suggested earlier is actually true: In the region of Cassiopeia and Cygnus there are rifts ablaze with stars. But moving through Pegasus and down toward Pisces and Cetus, the stars thin out remarkably so that in an entire binocular field of view there may be only a dozen or so stars in certain patches. The scarcity of naked eye stars here is simply a reflection of the fact that we're looking out toward a sparsely populated part of the Milky Way galaxy away from the main disk of stars.

Naturally you'll want to turn your binoculars toward M-31, the great Andromeda galaxy. The darker the night, the better you will see this galaxy. It will look much more interesting than the tiny out-of-focus dot that it appears to be with the unaided eye. In binoculars, it's an oblong blob with its center much brighter than the faint outlying regions; the longer you look at it the larger it seems to become. You'll get this impression even more if you try the averted vision technique where you don't look directly at it but choose a point somewhere off to the side while continuing to concentrate on the galaxy. The sensitive regions of your eye just away from the central line of vision will allow you to pick up some of the fainter outer edges of this distant star city.

Have An Astro-Christmas This Season
Give someone a gift of cosmic beauty

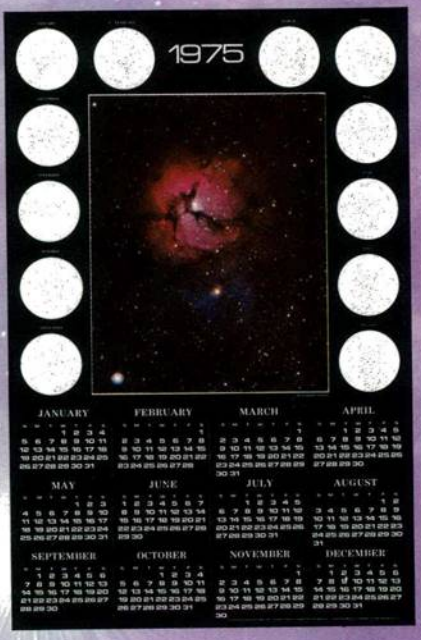
Our 1975 Trifid Calendar is now available — just in time for Christmas. And the popularity of our framed and unframed Mars and Milky Way lithographs makes them an ideal Christmas gift idea. Calendars and unframed lithographs are printed with painstaking care, rolled — NOT FOLDED — and shipped to you in mailing tubes. To insure that your order arrives in A-1 condition, effective immediately we will ship calendars and unframed lithographs via first class mail.

Milky Way in Sagittarius

The detailed cover photograph of ASTRONOMY's March 1974 issue is now a colorful 17 x 22 inch blow-up lithograph. A host of celestial objects at our galaxy's core are recorded in full color in this breathtaking photograph by Orien A. Ernest. The gossamer, golden beauty of the Sagittarius star clouds is revealed in magnificence unsurpassed by any other color Milky Way photograph. This beautiful lithograph is also available framed (21 x 26 inches) and ready for immediate hanging as shown above.

Framed price: $22.95 each
(Includes shipping and handling)
Unframed price: $2.50 each
(Includes first class postage)

1975 Trifid Calendar



1975 is just around the corner and in keeping with ASTRONOMY's Orion Calendar of last year, we've designed an even more beautiful 22 x 34 inch offering just in time for Christmas. This beautiful poster calendar shows a blow-up view of the Trifid nebula — one of the most colorful jewels of the universe — in the constellation Sagittarius. The photograph — one of the sparkling, new, color photographs from Kitt Peak National Observatory — has never been published this large before. Gossamer shadings of red and blue draw your mind into the depths of the awesome universe. Surrounding the photograph are 12 sky maps, one for each month of the year, making the 1975 Trifid Calendar not only beautiful but doubly useful. At the end of the year all you have to do is cut off the calendar portion and you will have a wall hanging of lasting beauty. Join the thousands who discovered the uncompromising beauty and quality of our Orion Calendar and order your 1975 Trifid Calendar today. What a timeless Christmas gift!
Price: $3.75 each (includes first class postage).
(Actual size 22x34 inches).

Mars as Seen From Deimos

The artistic imagination of Victor Costanzo is boldly displayed in this 17 x 22 inch full color lithograph of the red planet Mars as it would look from its outer satellite Deimos. Costanzo's painstaking accuracy in this rendition is given further credence because he incorporated real constellations in the sky background. To the lower left of the planet is the Hyades star cluster in Taurus, and to the upper right is the constellation Aries. This artwork was first used as a two page spread in ASTRONOMY's May 1974 issue to illustrate "The Lost Pictures of Mars" by Carl Sagan. This lithograph is also available framed (21 x 26 inches) and ready for immediate hanging as shown above. Framed price: $22.95 each (includes shipping and handling). Unframed price: $2.50 each (includes first class postage).

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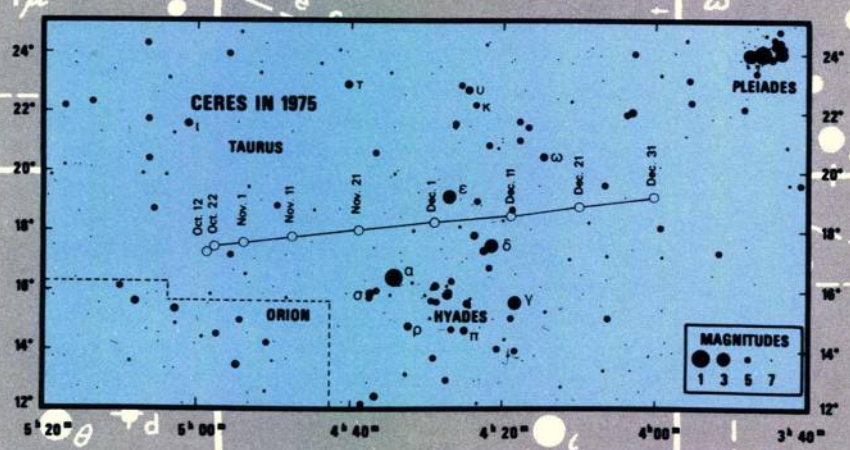
THE OBSERVER'S HANDBOOK 1975

EDITOR: DR. JOHN R. PERCY

For sixty-seven years, the most comprehensive guide to astronomical phenomena month by month. The *Observer's Handbook* is used by tens of thousands of amateur and professional astronomers, teachers, students, and others interested in astronomy.



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CONTRIBUTORS

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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
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BEHOLD THE ORION NEBULA

Imagine yourself as an inhabitant of an Earthlike planet orbiting Mintaka, the upper star in the belt of Orion, 1,500 light-years from the sun. You are sitting in your backyard waiting for the great event of the night. The stars shine brilliantly in the clear sky and what you are anticipating at last begins to happen. At first it's a pale glow on the horizon, but planetary rotation eventually brings it fully into view — a stunning, monstrous frozen cloud in the blackness of the night sky, brighter than any first magnitude stars and covering an area equal to 500 full moons. The colors, convolutions, wisps, and interplay of stars and gases covering a diameter of 25 light-years combine to assault your visual senses.

What we've just described is the picture at a distance of only 100 light-years from the Orion nebula. For us here on Earth, 1,400 light-years away, we still get a pretty good view of the big nebula. It's a fourth magnitude object in the constellation Orion visible as a hazy star to the unaided eye. In a small telescope we can easily make out its wispy cloudlike nature. However, the view from the backyard on our hypothetical planet of Mintaka can only be duplicated by long exposure photographs taken by larger telescopes.

Perhaps the finest color photograph ever obtained of the Orion nebula was taken this year through the new 158 inch Mayall telescope at Kitt Peak National Observatory near Tucson, Ariz. The photo is reproduced on the following two pages. Although the eye would see this nebula in somewhat different colors than are recorded on the Ektacolor-L film used by William Schoening of the Kitt Peak staff, the beauty of the interstellar cloud is exquisitely captured.

Kitt Peak National Observatory Photograph
(pages 32 and 33)

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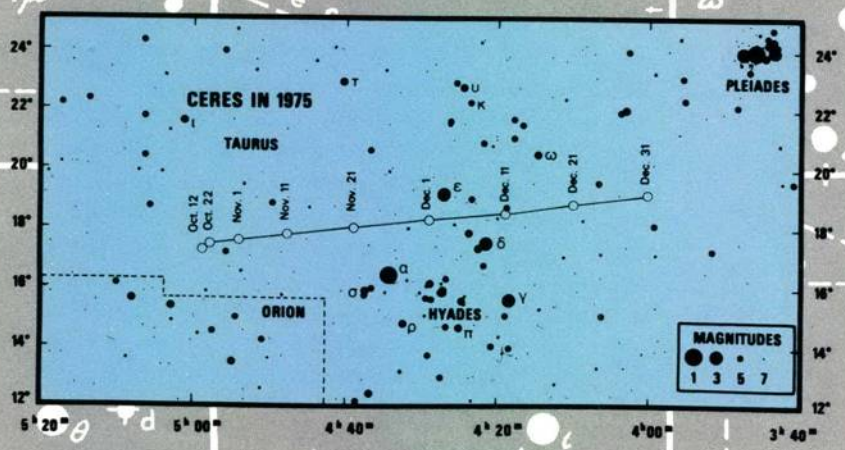

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Sky Photography Without a Telescope

by
Leo C. Henzl Jr.

What do you need to get started in astrophotography? A clock driven telescope, perhaps, and a home darkroom? A high altitude location and hours of leisure time? Exotic cameras galore and a freezerful of special emulsions?

Not really. Using common color slide films you can shoot many rewarding astrophotos with the simplest of equipment — just a camera, tripod and cable release. In a pinch, it's possible to get along with even less — as illustrated by the aurora photo on page 39. The display caught the photographer quite unprepared, with nothing more than a 35mm camera along for some snapshooting at a campground. In lieu of tripod and cable release, the roof of a car served as a camera stand, while several band-aids taped together locked the shutter open for the necessary exposure time. Significantly, other better equipped campers didn't bother to point their cameras skyward — maybe not realizing that they could photograph an auroral display with items normally toted in their camera bags.

Other celestial subjects that lend themselves to photography with the same simple equipment include star trails, meteors, constellations, other interesting groupings of moon, stars and planets, brighter comets, and lunar eclipses — virtually

Occasionally several planets and the moon cluster in the morning or evening sky. In this photo (taken early in the morning on August 14, 1966), all the naked eye planets except Saturn are visible: Mercury is just above the trees; Venus, much brighter, is between Mercury and the moon; Jupiter is the brightest "star" to the right of the moon; Mars is slightly below and left of Jupiter. Pollux and Castor in Gemini are above and to the left of the moon. The 10 second exposure on Kodachrome-X film was taken with a tripod mounted camera of standard 50mm focal length.

Photograph by Charles Capen

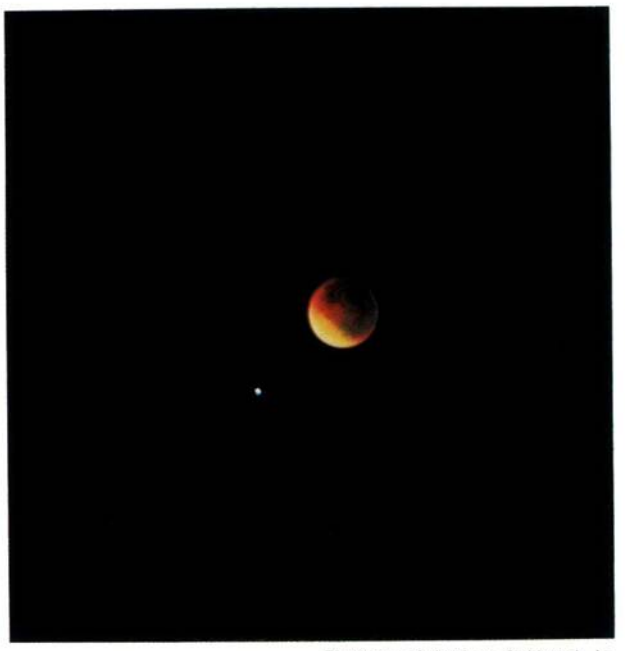
anything visible to the unaided eye. City dwellers, note: If you can *see* stars, you can *photograph* them.

For most of these subjects, practically any camera is suitable provided only that its shutter is adjustable to permit time exposures. Even this is unnecessary with some of the newer automatic cameras employing electronic shutter control; simply tripping the shutter in darkness will yield an exposure time typically of about 30 seconds — just right as a maximum for the majority of subjects. If a particular project requires a lesser exposure, merely cover the lens with a piece of black paper at the appropriate moment.

Although you can successfully photograph any of the phenomena mentioned with the "normal" lens of 50mm or so focal length on a 35mm camera, some subjects will frame up more pleasingly with lenses of different focal lengths. A memorable aurora, for example, may span 100 degrees or more of sky, so its complete extent would require a lens of less than 20mm focal length — an ultrawide-angle optic. At the other extreme, a lunar occultation sequence will occupy no more than about a degree of sky, so a longer focal length lens (300mm or more) is necessary here. With most subjects, however, the more ordinary wide-angle, telephoto and zoom lenses — from 28mm to 200mm — will do a fine job.

To photograph constellations or other subjects that include stars in the same field, your camera lens should generally be f/4.0 or faster. This is necessary because the hourly apparent motion of stars from east to west places a definite time limit on any exposure, and exceeding it will record streaks rather than stars. A relatively fast lens is necessary to deliver enough light to the film within the prescribed time.

The exposure time limit for a given subject depends on two factors — the focal length of the lens employed, and the declination (or celestial latitude) of the object you wish to record. Telephoto lenses, with their greater image scales, will resolve star motion in a shorter exposure than normal or wide-angle lenses. The precise time limit will also depend, to a large extent, on how much star trailing you're willing to tolerate — a matter for experimentation. As a general rule, though, if you're shooting in the direction of the north celestial pole — as far away as the Big Dipper — you will probably not find trailing



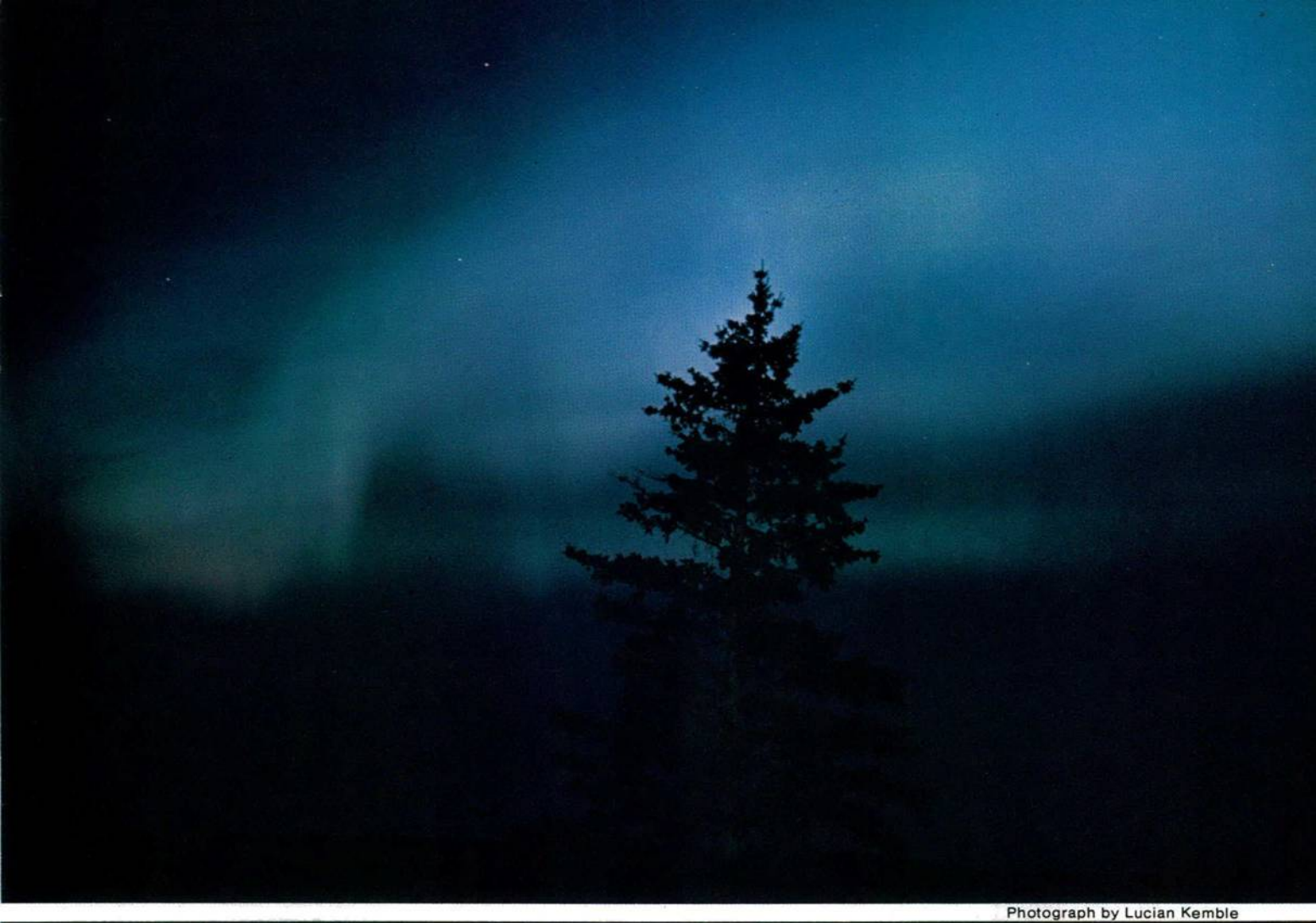
Photograph by Leo C. Henzl Jr.

An eclipse of the moon is always an occasion for astrophotography. As this photo illustrates, you don't need a telescope to capture the beauty of the event. A tripod mounted camera with a 135mm lens was used for this five second exposure at f/5.6 on High Speed Ektachrome.

Photograph by William E. Brown

Comet Bennett — the brightest comet in recent years — was an early morning object on Easter Sunday, 1970. A tripod mounted camera (without a telescope) was used for this 30 second portrait on High Speed Ektachrome.

A 10 to 30 second exposure with an ordinary camera on a firm support can result in sky photos well worth the effort. Indeed, the finest aurora photos have been taken with just such modest methods. In the lower photo the constellation Cassiopeia, easily identified by its "W" shape, is framed by an auroral curtain and leafless trees. A tripod mounted camera with a standard 50mm lens was used for both of these High Speed Ektachrome photographs. As explained in this article, it is remarkably easy to shoot this type of sky portrait. Photograph by Von Del Chamberlain



Photograph by Lucian Kemble

objectionable in a 30 second exposure with your standard 50mm lens. As star trail photos like the one on page 40 show, however, the apparent motion of celestial objects increases with increasing distance from the celestial pole. Thus, to photograph a constellation like Orion — near the celestial equator where hourly motion is greatest — reduce your exposure time to 10 seconds for reasonably pointlike stars. For mid-latitude objects, use a time between these two extremes.

The time limit is a simple proportionality for lenses of other focal lengths. Your 28mm lens, for example, being approximately 1/2 the focal length of your standard lens, permits exposures roughly twice as long. For lenses of the most popular focal lengths, the exposure time limits are as follows:

Declination of Object	Focal length of lenses 28mm	50mm	135mm
+60 - +90	50 sec.	30 sec.	10 sec.
+30 - +60	35 sec.	20 sec.	6 sec.
0 - +30	18 sec.	10 sec.	3 sec.

Because these times are relatively short — as astronomical exposures go — it pays to use the fastest film without objectionable grain. Any of the medium and high speed color slide films featured in last month's article on film testing will be more or less satisfactory, but those of ASA 100 or faster (Fujichrome R-100, High Speed Ektachrome, GAF 200 and GAF 500) are definitely preferable. Medium and high speed black and white films such as Kodak Plus-X and Tri-X have recording power equal or superior to the slide films, but unless you are prepared to do your own film processing and printing — so that you can "coax" these emulsions to sufficient contrast for esthetically pleasing pictures — you'll probably find the slide films more appealing, and a lot less work! And, after all, the beautiful hues of many celestial subjects are what may inspire you to commit them to film in the first place.

One precaution to observe in shooting any astronomical subject on color slide films: The commercial film processor may not be able to distinguish the dark sky background of your actual photos from the blackness of the unexposed film between frames. Nothing is more frustrating than to have a 36 exposure roll returned

During those rare, brilliant auroral displays, flickering veils of color seem to radiate from overhead. This photo is a 30 second exposure on High Speed Ektachrome with a 50mm lens at f/2.0. It was taken without a normal tripod for support. (See text for details.)

Photograph by Leo C. Henzl Jr.

perfectly processed and mounted, but with every frame cut right down its center! Therefore, since most labs center only the first or last frame of a roll by hand and then leave the rest to automatic cutters, it is wise to fill one of these frames with a brightly lit, easily identified terrestrial subject to serve as a cutting reference.

Once you've chosen appropriate lens and film combinations, the actual procedure for astrophotography without a telescope couldn't be simpler. A lightweight tripod is perfectly adequate for steady support of common focal length lenses in anything but a gale, and the only additional equipment necessary is a locking cable release and a watch with a "sweep-second" hand. A lens hood will help to exclude extraneous light and prevent dewing. Check to see that your lens is focused at infinity for most subjects, use an f-ratio from f/1.4 to f/4.0, point and shoot.

The one area of stationary camera photography wherein you may find it necessary to use a slower f-ratio is star trail photography or its close relative, meteor photography. To obtain star trails of appreciable length, or to keep your shutter open long enough for the law of averages to net you a meteor, you will need an exposure time of at least 30 minutes. In locations near major cities, this may result in film fogging with low numerical f-ratios or fast films. This, like the extent of tolerable star trailing, is a matter for experimentation. But as a starting point, most typical rural locations should permit 30 minute exposures at f/4.0 with ASA 100 film.

In constellation photography, you will generally want to use the widest lens opening possible and follow the exposure limit guidelines given earlier. Using a very fast film such as GAF 500, you can record stars to and even below the naked eye visibility limit, plus the brighter nebular objects, in exposures of less than 30 seconds at f/2.8. Compiling a star atlas of color slides for your own location is not a difficult project. Since the more southerly subjects have a lesser exposure limit, you may wish to shoot these with a wider lens opening in the interest of consistent sky background and approximately comparable magnitude limits for all constellations. Shooting north, middle, and low latitude constellations at respective f-ratios of f/4.0, f/2.8, and f/2.0, using the time limit guidelines, will produce the desired result for the sky background — but wide aperture aberrations in typical camera optics make it difficult to draw generalizations about the consistency of magnitude limits on such a sequence.

Even bright comets are comparatively dim and diffuse, so here again the widest possible aperture and the longest tolerable exposure time for a given lens focal length and subject declination are in order. Since a bright comet is a true rarity, don't hesitate to use a lot of film and to exceed the exposure guidelines by a factor of several times. The results are worth the effort, and the final slide will be a prize possession — regardless of the appearance of the stars.

Because major auroral displays vary enough in their exposure requirements from one to another, it also pays to shoot plenty of film when the opportunity arrives. In general, as with comets, you'll want to use the longest permissible exposure and widest lens opening. Some displays, however, exhibit such rapid fluctuations in shape and brightness that the longest permissible exposure may blur the definition of subtle rays and streamers. You'll improve your chances for a spectacular aurora slide with a sequence of exposure times from 10 to 60 seconds, spaced at 10 second intervals.

The coppery disk of the eclipsed moon is also a memorable subject for photography, but here you'll want to use a lens of at least 135mm focal length to obtain a suitably large lunar disk. A lunar eclipse is also a natural for sequence shooting — a series of exposures, each spaced about 10 minutes apart, displaying the event from beginning to end. Remember, though, that the moon's intensity may change considerably during the course of the event — so exposures must be chosen accordingly. With ASA 100 film, a good starting point for the uneclipsed moon is about 1/500 second at f/5.6 — with a gradual increase throughout the sequence to about eight seconds at totality. (The next total lunar eclipse visible from North America will be May 25, 1975.)

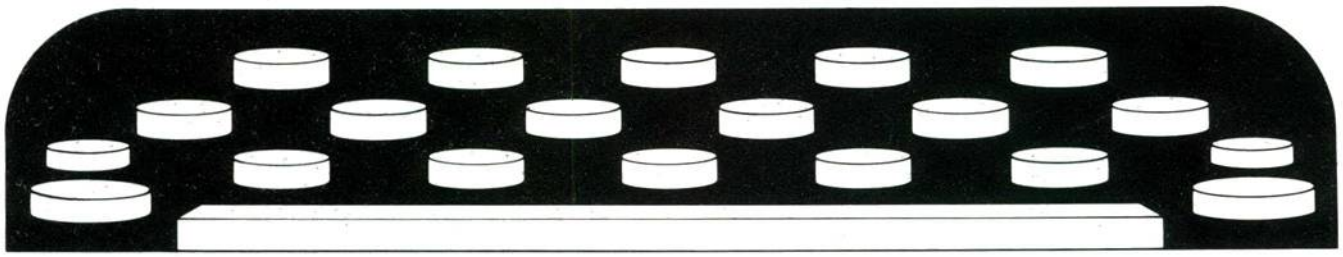
If there's any secret to successful astrophotography without a telescope, it is simply: Don't be afraid to waste film on your first efforts. The exposure guidelines presented here will net you something for your efforts, but you may find the results at half or double the recommended times to be more pleasing to you personally. Experiment and keep careful records of times, lens openings and results. Before long, you'll be able to step outside, assess the condition of the air, and confidently shoot only a few frames.

We look forward to seeing your results!

For further information see "It's Simple to Photograph Constellations", November 1973, and "Catch a Falling Star", August 1974.

An aircraft and satellite trail add a man made aura to this celestial portrait. Centered on the constellation Cepheus, the 50mm lens was left wide open at f/1.7 for an hour, allowing the stars to trail due to Earth's rotation. Like all other photos in this article, only a normal camera and tripod were used.

Photograph by James Elwell and Dale Olds



IN FOCUS

Sir / Your reference to a transparency rating in the September 1974 issue (page 49) suggests that your readers might be interested in a test of transparency that I have been using for several years.

It is very simple: I center Polaris in the low power eyepiece of my telescope (a 4-1/4 inch reflector) and count the number of stars visible. This eyepiece gives me a true field of 40 minutes of arc, and on a clear night there are 10 stars visible in this field. If the count drops to seven or eight I know not to waste my time searching for dim objects, and if it goes down to around five I confine my observations to the brightest open clusters and doubles.

For example, on a "10 star" night NGC-253 (the big galaxy in Sculptor) has a good sharp outline, but when the Polaris field shows only eight stars the galaxy is still fairly bright but is fuzzy around the edges.

The best reason for using the field of Polaris as a check point is that it is available year round, so that comparisons of transparency can be made on a month-by-month as well as a night-by-night basis. Then too, since users of equatorial mounts usually align the polar axis by sighting on Polaris, we can get an estimate of the clearness of the atmosphere at the beginning of the evening's work and plan our observations accordingly.

There are, of course, some disadvantages to this test. The most obvious is that conditions in the vicinity of Polaris are not necessarily those in another part of the sky as moonlight, city lights, and variable cloudiness may make these conditions better or worse than in the areas to be observed subsequently.

Fortunately there is a wide enough range in the brightness of the stars of the Polaris field to provide a reasonable estimate of atmospheric transparency without too much reliance upon purely subjective judgement.

GEORGE N. DOVE
Johnson City, Tenn.

Sir / I didn't really expect to see so many meteors — but I counted 58 in three hours on Sunday (Aug. 18). I also counted 30 between 12:15 a.m. and 1:15 a.m. Monday, Aug. 19 — 10 of which left trails.

I thought astronomy had one thing missing: movement. But I see that I was wrong.

JOHN CRANE
Mesa, Ariz.

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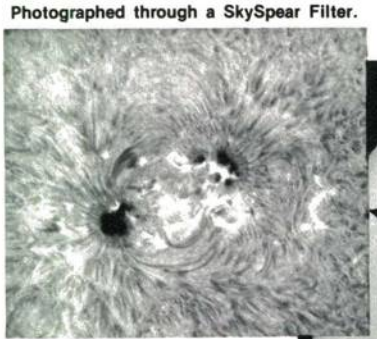
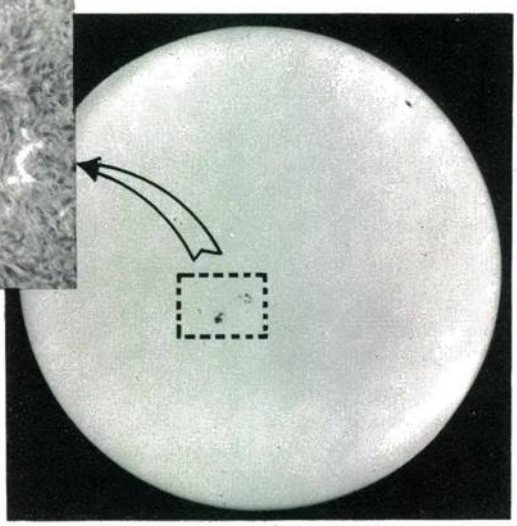
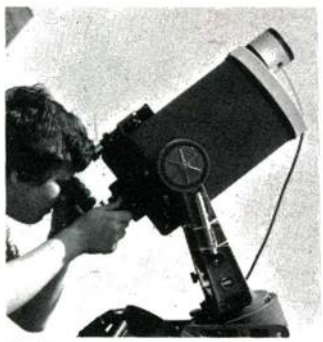
Photographed through a SkySpear Filter.





Photographed through conventional neutral density filter.



SkySpear Filter mounted on an 8" Celestron telescope.

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Sir / I am an avid reader of ASTRONOMY and was intrigued upon reading several of your articles mentioning the existence of "metallic" hydrogen on Jupiter. According to the June issue (page 23), the hydrogen is crushed to a density greater than that of lead by immense pressure and temperature of the planet.

I consulted my chemistry teacher who denied the existence of "metallic" hydrogen stating that it is a contradiction to call it so. "Metallic" hydrogen would have to be ductile and/or a conductor of electricity among other things to be classified as being actually metallic. Are you merely using a generalization or is the hydrogen on Jupiter actually metallic?

MARK NASSON
Belmont, Mass.

Mr. Nasson / Sorry your chemistry teacher hasn't heard about metallic hydrogen. There are billions of tons of the stuff inside Jupiter. It's responsible for the planet's magnetic field, among other things.

Sir / It seems your magazine has finally come of age; and, if there are many more people like Ben Bova, so has mankind. Could it be that we are actually approaching *our* "Childhood's End"?

ALAN CRING
Sunbury, Ohio

Sir / ASTRONOMY is the only magazine that I read from cover to cover with fascination. I particularly like your presentation of theory and the astoundingly beautiful photographs — but all aspects of astronomy are covered well.

DREW R. FISHER
Dayton, Ohio

Sir / On Aug. 11-12 between 10:30 p.m. and 2:00 a.m., we observed approximately 90 meteors. Sleeping bags, an open pasture and a beautiful, clear night sky allowed for extraordinary viewing. We appreciated your informative article providing us with time and location data.

C. LAMSON and
J. B. CORSIGLIA JR.
Ashburnham, Mass.

Sir / I enjoyed the fine article in the September 1974 issue by James K. Rouse on astrophotography. However, I have a question about some of the figures quoted.

The scope was described as an eight inch f/7 Newtonian reflector. This I understand. Later, in discussing test shots of Jupiter, he stated he used a 7mm eyepiece for projection at f/80. A ratio of f/105 was used for Mars. There is apparently some convention that I do not know that enables one to express projected images in terms of f-ratio.

LEROY A. WOODWARD
Atlanta, Ga.

Mr. Woodward / Briefly, the size of a projected image depends on the effective focal length of an optical system. At the basic, 56 inch f/7 Newtonian focus of Rouse's telescope, the scale of a projected image is almost exactly one degree per inch of film. At this scale, the diameter of Jupiter's image would be only 0.0125 inches — too small to disclose any real detail. Therefore, Rouse inserts an eyepiece between his telescope and film to increase his effective focal length suitably and to project an enlarged image. As his effective focal length is increased, so is his effective focal ratio — because his aperture remains constant at eight inches.

Actually, then, what we are saying when we describe a Jupiter photo as shot at f/80 is that an effective focal length of 640 inches was employed with the telescope. The main purpose in doing this, however, is to provide readers with the basic exposure information needed for similarly fine results, whatever the aperture of the telescope employed. For this purpose, the effective focal ratio in a photo caption is more useful information than focal length alone.

Formulas and methods of computing will be comprehensively covered in a forthcoming article.

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ASTRONOMY

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In response to requests from our readers and schools, ASTRONOMY has just published a cumulative index to Vol. 1. This subject index covers August, September, October, November and December, 1973, which includes issue Nos. 1 through 5. Index to Vol. 1 is available for $1.00 each, including handling and first class postage.

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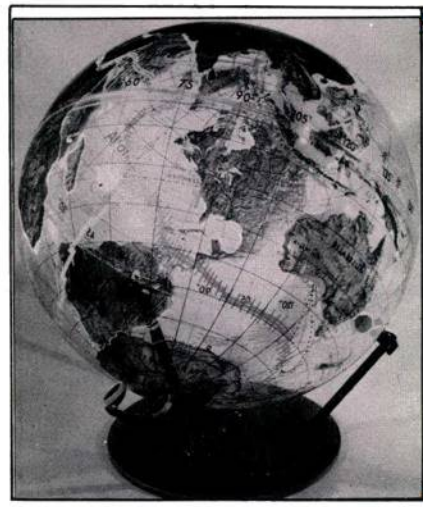

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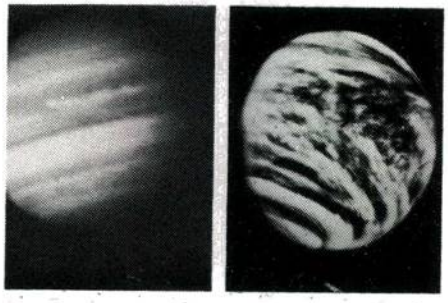

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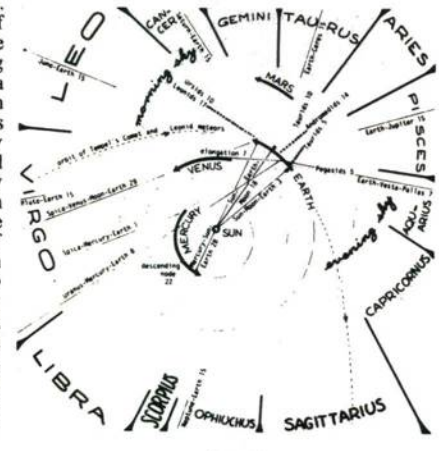

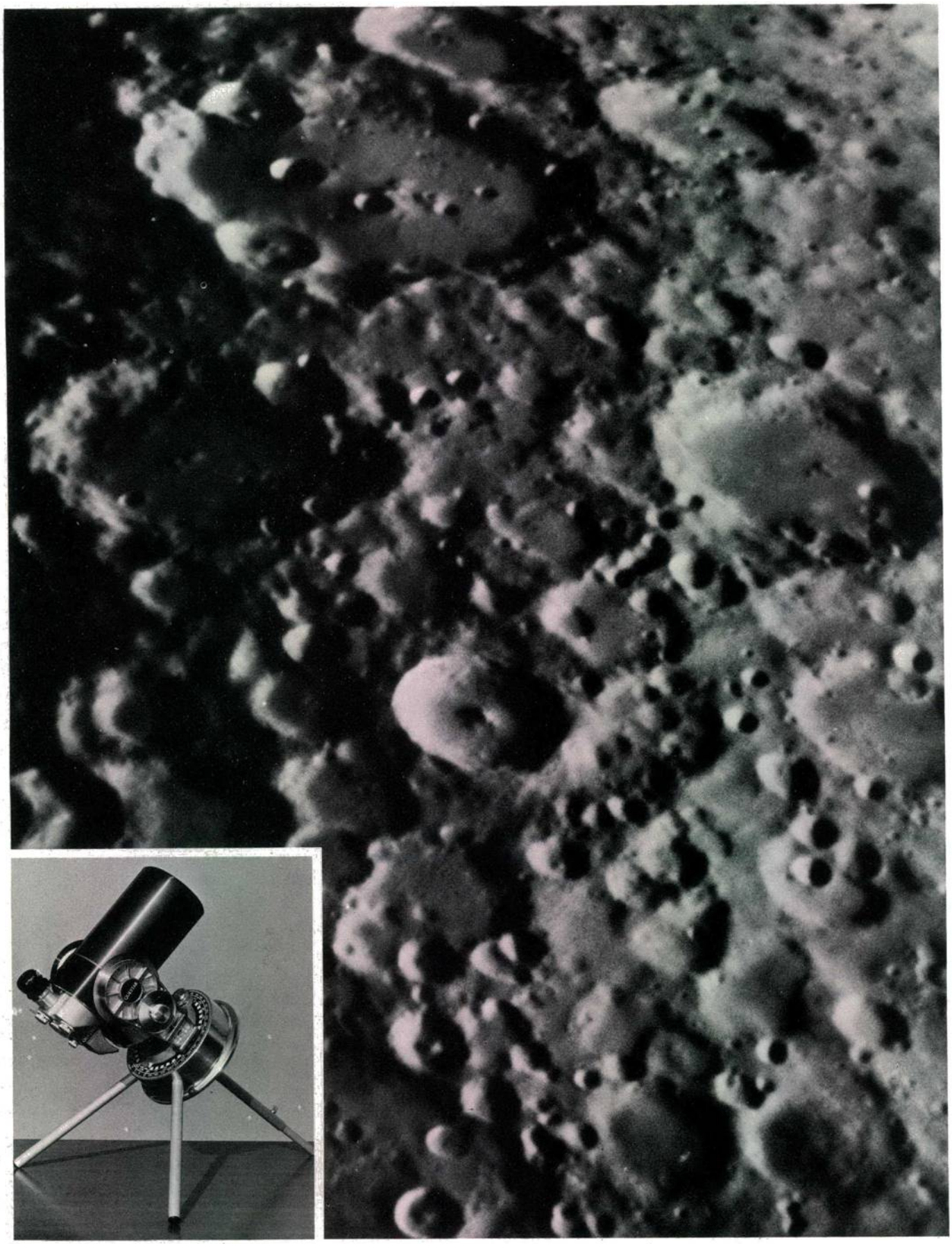

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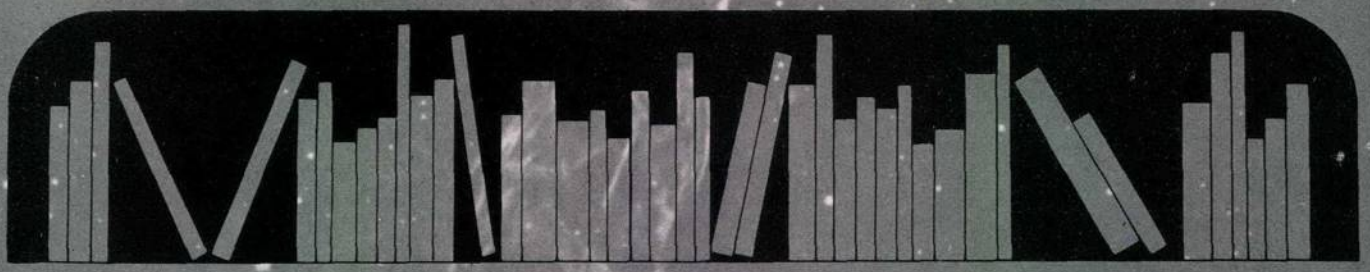


The Tiny Planets: Asteroids of Our Solar System

by DAVID C. KNIGHT

96 pages, hardcover, $3.95
Morrow and Co. (1973)

This modest volume takes up where most introductory astronomy books leave off. Normally the assorted debris of the solar system is treated as a "leftover" at the end of the chapter on planets and satellites. The asteroids — their discovery, possible origins, and uses to astronomy — form the subject matter for a little-known but fascinating chapter in solar system studies.

The large gap between Mars and Jupiter was noticed early in the history of modern astronomy as outlined by Michael Ovenden in last month's feature article. But Knight reveals that the history of the discovery of minor planets is far more complex than the abridged version found in most textbooks. What is most valuable in **The Tiny Planet** is the sense of excitement and discovery associated with working out the puzzles in the sky.

There is a lot packed into this brief book: details on the sizes and shapes of asteroids; the implications of the Kirkwood gaps and Trojan asteroids; the Hirayama groups; odd planetoids like Eros, Icarus and Toro, and more. Examples from studies of asteroids are used to illustrate principles of planetary motion, astronomical methods, and the development of science.

The book might be a trifle better organized, and in some areas better engineered to keep a young reader's attention. Some subjects are touched on and too soon forgotten, while others are stretched (one is tempted to say padded) to the point of boredom. But even that can be counted as a plus. The book can serve well as an introduction and an invitation to further reading. A young person intrigued by this book might someday become the first human being to walk on Ceres, Eros or Vesta. That's part of the promise and excitement of today's astronomy.

Carrying the Fire: An Astronaut's Journeys

by MICHAEL COLLINS

478 pages, hardcover, $10.00
Farrar, Straus, and Giroux (1974)

Who hasn't spent at least one evening in a bar or at some party, listening to hour after hour of so-called "war stories"? Some pilot just back from "MIG Alley" or the Tonkin Gulf relates his adventures in a style all at once graphic, pointed, and humorous. That's the way it was, he declares, and we really understand the way it was.

This elusive quality called "style" has got to be one of the finest aspects of Michael Collins' tale of astronaut duty. The book is impossible to put down and once finished, impossible to lend to a friend. You want to start reading it all over again!

The author was involved with most of the United States manned space program between 1963 and 1969, and so the book — although written from a personal point of view — is really a complete description of the Apollo project in general. Conveying the flavor of those years, of transmitting what it was really like "out there", requires more than just a chronicle of events and dates: It needs the personal, irreverent, witty and lucid style such as Collins displays in this remarkable book.

As a 33 year old Air Force major, Collins joined the astronaut program just as the Mercury project was ending. He was copilot of the three day Gemini 10 flight in 1966, and was command module pilot of the world's first moon landing flight — Apollo 11 — in July 1969. Along the way he was a "spacewalk" project officer, served as backup pilot on several Gemini and Apollo flights, was assigned to and removed from the Apollo 8 moonflight for spinal surgery, and ultimately passed up a chance to walk on the moon on Apollo 17.

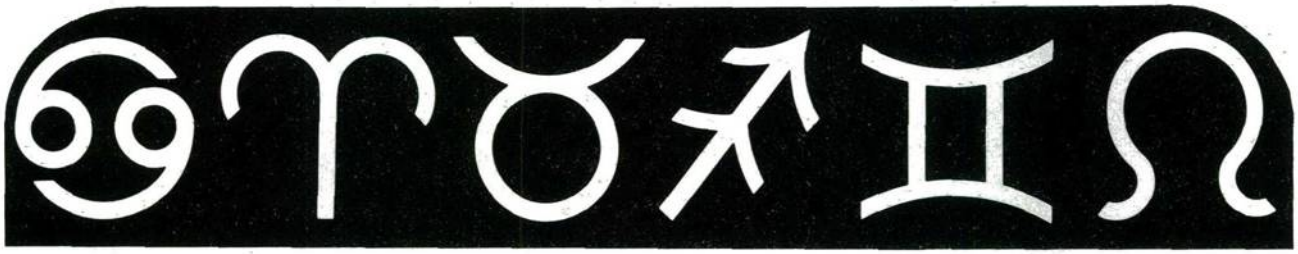
One of the points stressed by reporters and newsmen during the Apollo 11 flight was the "aloneness" Collins must have felt in the command module Columbia while his two crewmates flew the Eagle down to the moon. Behind the moon, Collins was totally cut off from Earth, with "the score... three billion plus two over on the other side of the moon, and one plus God only knows what on this side."

Back on Earth, Collins discovered that the world remained the same but that his own sensitivity did change a bit. "My threshold of measuring what is important has been raised," he related. Outside of any permanent benefits, he felt a deep sense of satisfaction, looking back at the moon landing "with a mixture of pride, incredulity, and smugness."

His two space flights changed his perception of Earth, but the Apollo moon flights did the same for millions more who never left the planet. Collins enjoys quoting Fred Hoyle, a noted British astronomer who pointed out more than a quarter century ago that the first space pictures of the whole earth would have a stunning impact on human thought and would unleash a flood of new ideas. Perhaps the image of the "fragility" of "the grand oasis in the great vastness of space" was of critical importance to the growth of the ecology movement.

With public attention swinging from space to pollution, Collins philosophizes about "the American tendency to be faddish, supporting 'in' things blindly and just as blindly rejecting the passe." It was a dreadful mistake, he feels, but somehow "Apollo 11 was perceived by most Americans as being an end, rather than a beginning....The space program was too popular before the first lunar landing and not popular enough after it."

In the cyclic nature of public attention, space flight is out of favor these days. As a historical record of the Apollo feat, Collins' book will probably become the classic narrative of the U. S. space program in the 1960s. But just as important, it will interest, intrigue, and challenge the hearts and minds of the men and women who will carry out the next stage of space exploration, as the pendulum swings back and the Space Shuttles carry the fire into the 1980s.



CONSTELLATION CLOSE-UP

Cassiopeia

by
Thomas C. Bretl

High in November's northern skies, Cassiopeia is one of the best known of all the constellations. Grade school children are introduced to "her" in their science courses, and every stargazer, young or old, soon becomes well acquainted with this distinctive "W" shaped group of stars. Cassiopeia contains none of the most celebrated celestial showpieces, however, and is often neglected by telescopic observers. This is unfortunate since there are strikingly colorful double stars

TABLE OF OBJECTS IN CASSIOPEIA

Double Stars

Star	Mag.	Sep.	Colors	R.A.	Dec.
σ	5.1 - 7.2	3.1"	Green, blue	23^h58^m	$+55°38'$
η	3.6 - 7.5	10.1"	Yellow, purple	00^h47^m	$+57°41'$
$\Sigma 163$	6.2 - 8.2	35.0"	Red, blue	01^h49^m	$+64°43'$
ι	4.7,7.0,8.2	2.7"	Yellow, blue	02^h28^m	$+67°18'$

Galactic Clusters

NGC	Overall Mag.	Mag. (Stars)	Size	R.A.	Dec.
103	11	11 - 18	13'	00^h24^m	$+61°12'$
129	10	9 - 13	11'	00^h29^m	$+60°05'$
225	9	9 - 10	12'	00^h42^m	$+61°39'$
457	8	7 - 10	10'	01^h18^m	$+58°12'$
559	7		7'	01^h28^m	$+63°11'$
581 (M-103)	7	10 - 11	5'	01^h32^m	$+60°35'$
654	10	6 - 7	5'	01^h42^m	$+61°46'$
659	10		5'	01^h43^m	$+60°35'$
663	7		11'	01^h44^m	$+61°07'$
7654 (M-52)	7	9 - 13	12'	23^h23^m	$+61°27'$
7788	9	10 - 16	2'	23^h56^m	$+61°15'$
7789	10	11 - 18	30'	23^h56^m	$+56°35'$

Epoch 1970

Photograph by Leo C. Henzl Jr.

to be found here, as well as an extraordinary number of beautiful star fields and rich galactic clusters.

Starting in the northwest corner of the constellation, the first noteworthy cluster we find is M-52, one of two Messier objects located in Cassiopeia. M-52 is a bright, irregularly shaped cluster with a diameter of about 15 minutes of arc. Its stars range in magnitude from 9 to 13, giving it a total magnitude of seven and making it a very suitable target for small telescopes. Dreyer's **New General Catalogue** (the NGC catalog) accurately describes M-52 as rich and much compressed toward its middle, and many observers have noted a conspicuous orange-red star contained within it.

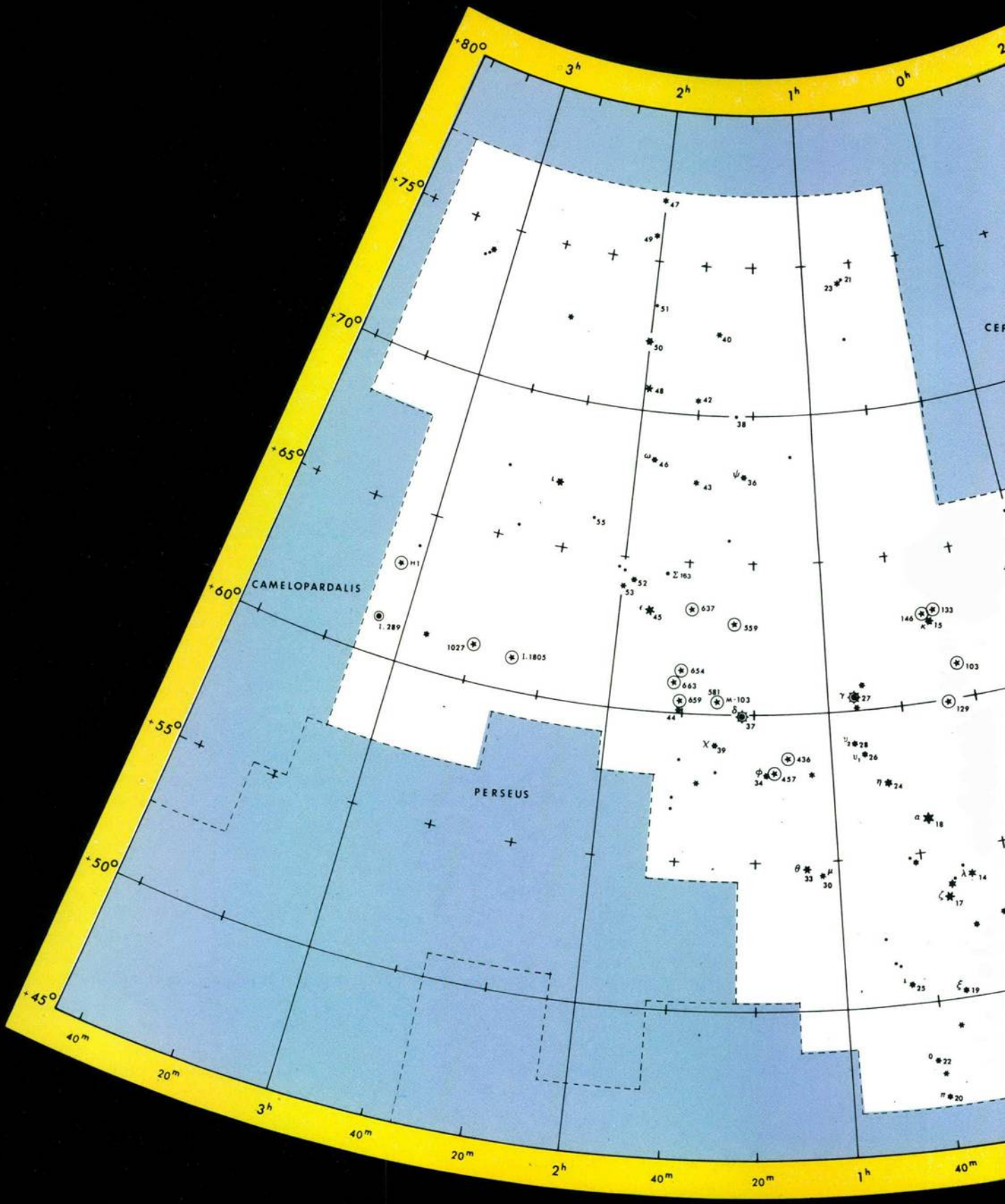
M-52 is only a good place to begin, however, for the catalog lists more than 20 other bright clusters that lie within Cassiopeia's boundaries. Moving a short distance eastward (about three degrees northwest of second magnitude Beta Cassiopeiae), are three more open clusters, all grouped within 1/2 degree of each other. Two of these are difficult to distinguish against the star rich background sky which surrounds them, but the third, NGC-7788, shows up well because of its small size and compact structure. Although only a ninth magnitude object, it contains a great many 10th, 13th, and fainter magnitude stars all packed within an area just a few minutes of arc across. In a small refractor it should appear as a faint fuzzy spot. Even a six inch reflector, while resolving much of the cluster, leaves it with an overall hazy appearance.

Five degrees directly south of NGC-7788 lies NGC-7789 — perhaps the most beautiful object in the entire constellation. This large, rich, and very compressed cluster contains hundreds of 10th to 18th magnitude stars and is an impressive sight in any size telescope. A six inch richest-field instrument reveals it as a softly glowing circular mass of stars, while a 12 inch scope brings out stellar patterns suggestive of a huge spider crawling across the field of view. Remarks made by Webb and Smyth in **Celestial Objects for Common Telescopes** describe it best as "a beautiful, large faint cloud of minute stars; a most superb cluster; a mere condensed patch in a vast region of inexpressible splendor, spreading over many fields."

With so many fine clusters to choose from, it would be easy to pass up the good double stars

that can be found in Cassiopeia. Some of the best are listed in this month's table of objects. Iota Cassiopeiae is especially recommended, for there are few triple stars with such colorful components at such convenient separations. Σ163 is also a must. With a separation of 35 seconds of arc, it is a very easy pair to split, but the colors of the components are quite pronounced making for a striking field of view.

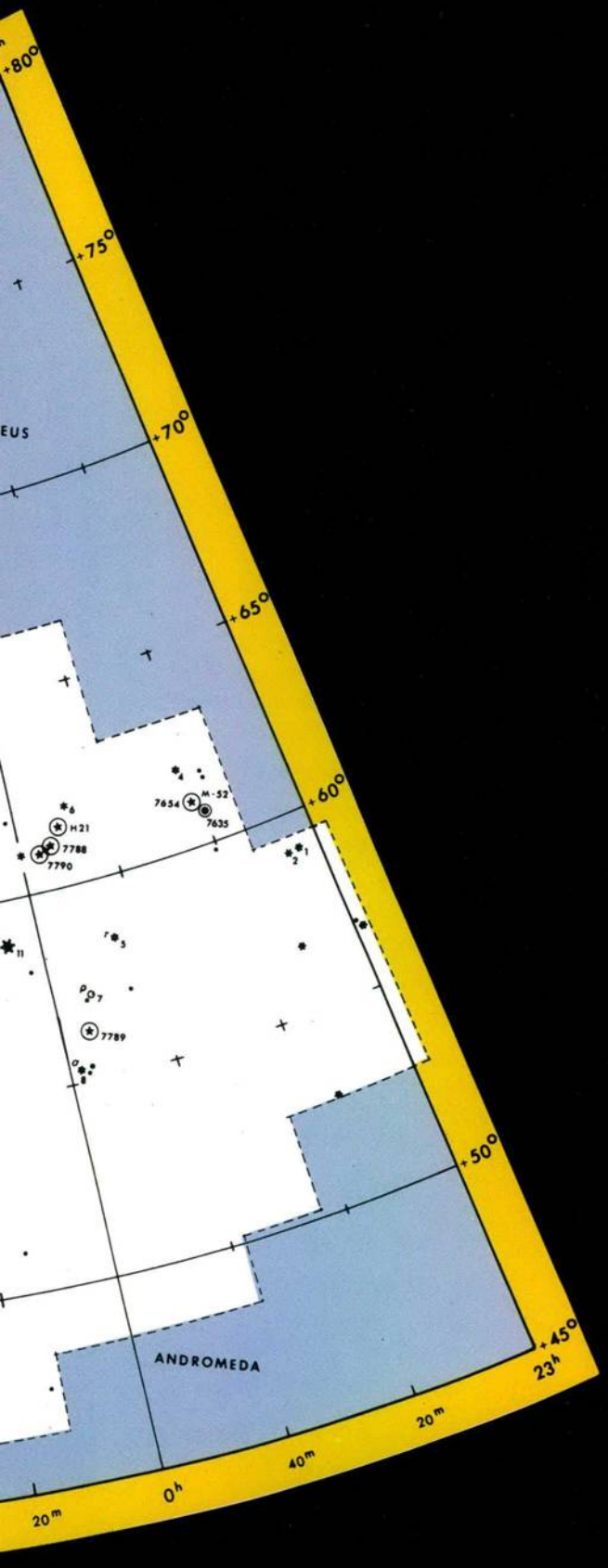
While searching for NGC-7788, you may very



well have been treated to the sight of another colorful double star that lies about halfway between that cluster and Beta. If not, take the time to go back and look for it. Nevertheless, the distinct colors involved (red and blue, much like Σ 163) are stunning and will immediately attract your attention. Use a low power eyepiece to obtain the most appealing view.

The area near Delta Cassiopeiae is another extraordinary region rich in galactic clusters. Cassiopeia's other Messier object, M-103, is located just one degree northeast of that third magnitude star. Three more clusters, NGC-654, NGC-659, and NGC-663, lie just two degrees farther away in the same direction. M-103 is a small, triangular shaped group which at first glance appears to be a sparse collection of rather bright stars. A closer look, however, reveals the glimmer of its many fainter members. NGC-663, on the other hand, is much larger; the minute you find it there is no doubt that it is an extremely rich cluster.

NGC-654 and NGC-659 neighbor NGC-663 to the north and south respectively, and both are a good deal smaller. In a six inch telescope, neither is completely resolved. (If a richest-field instrument is used, all three clusters fit beautifully within the same field of view.) This is indeed an area to sweep across slowly, using the lowest possible magnification — and so, in fact, is the entire constellation Cassiopeia. As we realized in Sagittarius and Cygnus, clusters are but the highlights of the endless star fields spread throughout the Milky Way. Certainly, they are "mere condensed patches in a vast region of inexpressible splendor, spreading over many fields."



Stellar Magnitudes

-1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Galaxies Planetary Nebula

Open Star Clusters Globular Clusters

Diffuse Nebula Double Stars Variable Stars

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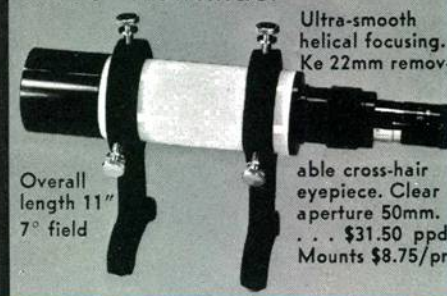

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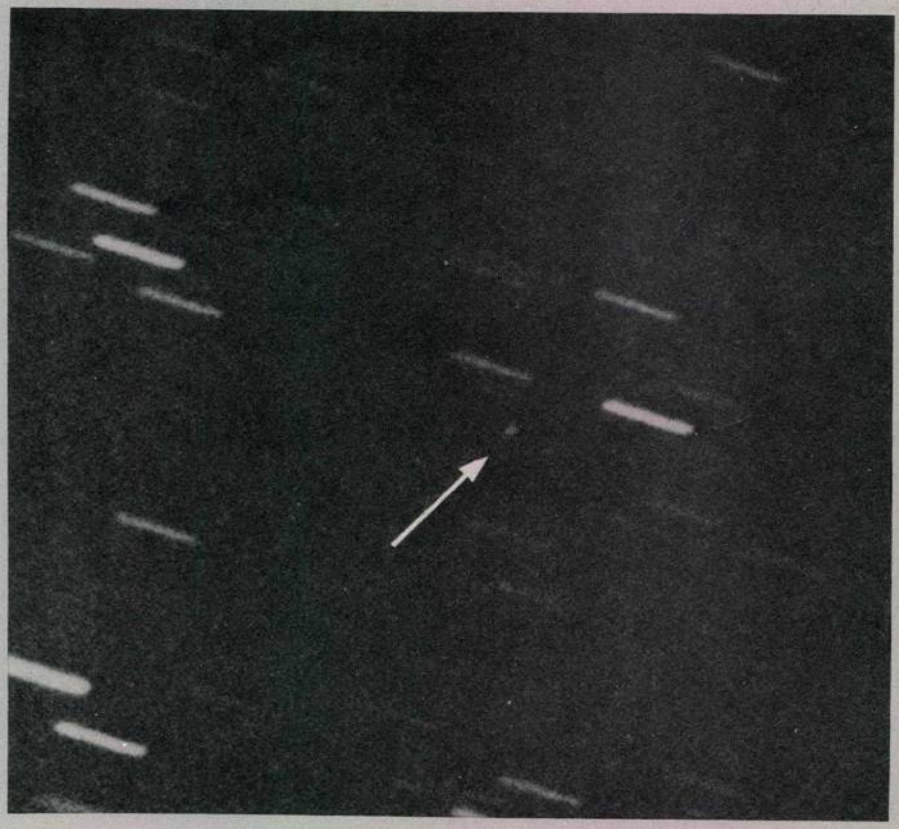
ASTRO-NEWS

Latest News From the World of Astronomy

13th Jovian Moon Discovered

What is presumed to be the 13th moon of the planet Jupiter has been discovered by Charles Kowal, a research assistant at the Hale Observatories in California. The discovery was made during a search for possible Jovian moons with the 48 inch Schmidt telescope at Mt. Palomar Observatory. Three photographic plates taken with that instrument contained the faint image of the suspected moon.

The newly discovered object seems to be moving through space with Jupiter, and this is taken as evidence that it is a satellite of that planet. However, Brian Marsden of the Smithsonian Astrophysical Observatory has computed orbits — based on the positions in the three photos — that show that the object could be either a very distant comet between the orbits of Jupiter and Saturn, or an asteroid that is close to the giant planet. But Marsden feels these are less likely possibilities. He believes the most logical interpretation of the available data is that the object is a satellite of Jupiter in a retrograde orbit about 14 million miles from Jupiter. This is the same distance at which four other small members of Jupiter's family of moons are orbiting, and all four also have retrograde orbits. (An object in a retrograde orbit moves clockwise, opposite the typical traffic pattern of the solar system.)



Hale Observatories Photograph

The newly discovered 13th moon of Jupiter showed up as a faint dot (arrow) among streaks made by stars in a two hour exposure photo taken by the moon's discoverer, Charles Kowal, with the 48 inch Schmidt telescope at Mt. Palomar Observatory. The moon is believed to be about five miles in diameter. Early calculations suggest it may be in a two year orbit, about 14 million miles from Jupiter.

If the object is in fact a new moon of Jupiter, it will be the smallest known natural satellite of any planet in the solar system. On the photographs it appears as an extremely faint 20th magnitude speck and cannot be much more than five miles in diameter. This makes it slightly smaller than Deimos, the eight mile wide outer moon of Mars. The new moon is so small that an observer near Jupiter would need an eight inch telescope to see it.

Most scientists believe the four outer moons of Jupiter and the newly discovered suspect moon are asteroids captured by Jupiter's immense gravity. Their retrograde orbits are further evidence for this view. Another theory is that the outer group of Jovian moons, plus three other larger satellites that orbit in a regular manner at seven million miles from Jupiter, were all produced by collisions among larger objects.

The last discovery of a planetary satellite — Saturn's 10th moon, Janus — was made by Adouin Dollfus in 1966. Jupiter's four largest moons were discovered in 1610 by Galileo just after the invention of the telescope. The fifth was discovered in 1892 by E. E. Barnard at Yerkes Observatory. The remaining seven, all less than 100 miles in diameter, were discovered by photographic techniques between 1904 and 1951.

(For additional information on the moons of Jupiter, see "The Forbidden Moons" in the May 1974 issue of ASTRONOMY.)

Interior of Giant Planets Simulated

By firing "bullets" at hydrogen in a solid form, a new research cannon is helping scientists learn about the solar system's two giant planets — Jupiter and Saturn.

The cannon is the brainchild of Thomas J. Ahrens, associate professor of geophysics at the California Institute of Technology, who has used it to test the compressibility of solid hydrogen. Hydrogen is the most common chemical element in the universe, usually appearing as a gas. As a solid, it exists on Earth usually in pressurized cylinders. It is believed to be plentiful as a solid on Jupiter and Saturn.

Ahrens and Peter Lagus, his associate, have determined that when hydrogen is subjected to pressures of 100,000 pounds per square inch, it becomes 30 percent denser than when it is initially frozen — a compressibility exceeding that of most solids. A clear lightweight substance, hydrogen becomes solid at a temperature of -434 degrees Fahrenheit. At this, its freezing point, it is 1/11 as dense as water.

Through a more precise understanding of the compressibility of solid hydrogen, scientists are better able to calculate its behavior at even higher pressures than they can create in the laboratory — pressures such as those existing in the interiors of the giant planets. Hydrogen is probably present in them in all its forms — gas, liquid and solid. It has been estimated that those planets are 90 percent hydrogen. The deeper inside the planet, the denser the hydrogen becomes. Under the tremendous pressures that exist within Jupiter and Saturn, solid hydrogen should be in a metallic state with the property of electrical conductivity. This electrical conductivity may give rise to Jupiter's strong magnetic field, which has been hard to explain by other hypotheses.

The insights gained through Ahrens' experiments can help in understanding data that are relayed by spacecraft or obtained through an analysis of radio waves about the surface and near-surface characteristics of Jupiter and Saturn.

"The more we know about solid hydrogen, the more accurately we are able to interpret the data," Ahrens said. "We can form better conclusions about the planets' composition, about changes in density of the hydrogen according to its depth within the planets, and about the amount of solid hydrogen that is present."

The research cannon that Ahrens and his co-workers used has a barrel 24 feet long that fires flat nosed bullets 1-1/2 inches in diameter into a 1,200 cubic foot vacuum tank. The bullets, whose velocities are controllable, can travel up to four times the speed of ordinary rifle bullets.

To obtain hydrogen in a solid form, the researchers first used liquid nitrogen to cool hydrogen gas in a stainless steel container down to -321 degrees Fahrenheit. The hydrogen became a liquid at that point. Using liquid helium, they next condensed the liquid hydrogen into a solid by lowering its temperature to its freezing point of -434 degrees Fahrenheit, and then to -452 degrees Fahrenheit. "This temperature, the boiling point of liquid helium, was the lowest that we could achieve," Ahrens explained.

With the hydrogen frozen, the scientists fired stainless steel bullets at the container. "The bullets impacted the container at speeds of 5,000 feet per second," Ahrens said. "The impact produced a shock wave in the solid hydrogen that rearranged its atoms into a more closely packed structure. The speed of the shock wave as it traveled through the target was measured by observing, with a high speed camera, its interaction with a delicate mylar foil that was 1/2000 of an inch thick. The foil had been immersed in the solid hydrogen."

New Measurement Finds Titan Largest Satellite

A new measurement of the diameter of Saturn's largest satellite, Titan, has shown that moon to be by far the largest in the solar system and about 20 percent larger than had been believed. Previous diameter determinations, centered around 3,000 miles, were the result of direct measurement techniques using large telescopes where astronomers tried to exactly determine the width of the tiny disk of Saturn as it appeared in the telescope.

However, the new determination made by J. L. Elliot, Joseph Veverka and J. Goguen of Cornell University employed a simple but previously unused technique for accurately measuring the sizes of satellites. Using the 88 and 24 inch telescopes of Mauna Kea, Hawaii, they watched as Saturn and its satellites were occulted by the moon on March 30, 1974. The length of time it took the edge of the moon to blot out the light from each satellite was measured precisely. Knowing the apparent rate at which the moon was moving, the times were then translated directly into satellite sizes.

Five Saturn moons were measured, but the big surprise was Titan where the diameter came out to be 3,600 miles — about 600 miles greater than almost all the estimates made in recent years.

The observations also revealed that the disk of Titan is strongly limb darkened; that is, the edge appears much dimmer than the central part of the disk. This is no doubt why visual observers underestimated the size of this satellite. However, one of the best visual observers of Titan, Bernard Lyot, did note back in the 1950s that under good seeing Titan does appear strongly limb darkened. For some reason, the visual diameter measurements were never corrected for the effect.

There is a major implication to this new diameter of Titan: It changes our concept of that moon from a rocky body with (perhaps) ice glaciers on its surface and a fairly dense methane atmosphere (about 10 times the density of the atmosphere of Mars) to a picture of Titan being almost entirely frozen methane, possibly with a small rocky core. The atmosphere surrounding Titan, of course, must remain in any "model" because it has been detected on many occasions. However the production and maintenance of the atmosphere of Titan and the nature of the surface of this giant of all moons will have to be somewhat revised because of the new and dramatic news that Titan is the largest moon in the solar system.

Jupiter's satellite Ganymede retains its title as the most massive of the planetary moons — at least for the present — being over twice the mass of Earth's moon. There is some indication that Neptune's big satellite Triton may be even more massive than this, but our knowledge of Neptune and its environment is too shaky for us to make any proclamations. But the new Titan measurements do come somewhat as a surprise and show the need for more precise observations of these objects which are worlds in their own right.

Solar System Moons Under Intensive Study

University of Arizona Photograph

This Pioneer 10 photograph of Jupiter's satellite Ganymede is the first detailed image of that object ever obtained. Although the light and dark patches resemble the appearance of Mars in a small telescope, no conclusions are being drawn since Ganymede's surface is believed to be more ice than rock.

There are 32 known satellites in the solar system — and were it not for the fact that they all orbit larger parent bodies, at least six of them would be respectable planets in their own right. But until recently they were virtually ignored by astronomers who, among other things, were busily observing quasars or theorizing about the origin of the universe.

Recently at Cornell University, planetary astronomers from all over the world gathered to discuss the latest observations and theories about these long neglected neighbor worlds. Here are some of the highlights of that conference:

The two baby moons of Mars, Phobos and Deimos are much better known now than they were a few years ago — thanks to the high resolution cameras of the Mars-orbiting Mariner 9 which snapped dozens of pictures of each moon.

From these photos Tom Duxbury of the Jet Propulsion Laboratory (JPL) has constructed maps of the surfaces of both of the tiny satellites. The map of Phobos shows virtually the entire satellite and the surface is saturated with craters including one which is five miles in diameter — fully 1/3 the size of Phobos. This crater now has an official name (Stickney) along with several of the other features on this satellite (see photo page 58).

Both of Mars' satellites are ellipsoids rather than spheres, with the longest axis always pointing toward Mars and the shortest axis running at right angles to their orbits. The dimensions of the two moons are now very accurately known. Phobos is 16.8 miles in its longest dimension and 11.9 miles in its shortest axis. Deimos is 9.3 miles long and 6.8 miles wide. For both satellites the period of rotation equals the period of revolution about Mars — in other words, like our moon they have synchronous rotation rates and only 1/2 of their surfaces are visible from the surface of Mars.

The satellites of Jupiter were the subject of many reports at the conference. One of the most exciting included a photograph of Ganymede made from recently processed Pioneer 10 imagery. Tom Gehrels of the University of Arizona worked on the photo, and noted that bright and dark markings are easily seen on the satellite but their interpretation is still

Study *continued on page 58*

Supergiant Galaxy Discovered Largest Object in the Universe

A radio galaxy two billion light-years from Earth is the largest object so far detected anywhere in the universe according to three astronomers who observed it with a Dutch radio telescope array.

A. G. Willis, Richard Strom and Andrew Wilson of Leiden Observatory, Netherlands, report that the radio source 3C-236 spans an area of the sky wider than the apparent diameter of the moon. But it is 50,000 trillion times farther away than the moon which makes 3C-236 at least 18 million light-years wide — 150 times the width of the Milky Way galaxy.

Despite its size, 3C-236 is really just a cloud of excited gas surrounding a superluminous elliptical galaxy. This giant galaxy, among the brightest known, is the energy source for its enveloping radio galaxy. (There is some confusing terminology here: A *radio galaxy* is the region "visible" in radio telescopes, whereas the word *galaxy* alone refers to an object like the Andromeda galaxy.)

The galaxy itself is a 16th magnitude object, but it is truly brilliant. If we could place the Andromeda galaxy at the same distance it would be a nearly invisible 20th magnitude speck in a 200 inch telescope photo.

The importance of the discovery is that the radio galaxy must have taken 10 times longer to form than the maximum predicted lifetime of a typical radio galaxy. Obviously that maximum will have to be revised. But in doing so, astronomers will be forced to rethink some of the concepts of the evolution of radio galaxies. It's all part of the continuing process of piecing together our evolving picture of the universe.

enigmatic. Our geological experience is limited to the surfaces of rocky planets and we have little, if any, idea as to what type of surface features we may encounter on planet sized iceballs such as Ganymede. The appearance of Ganymede from Earth under excellent observing conditions is shown in the drawing of an occultation of Europa by Ganymede as seen through a 43 inch telescope (see illustration, upper right).

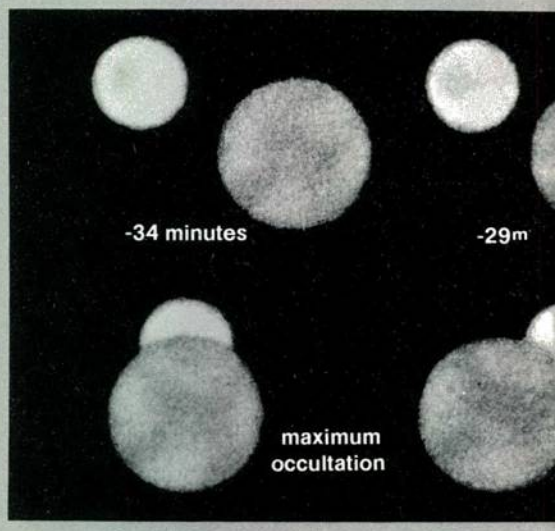
A variety of fascinating new results about Io, the innermost major satellite of Jupiter, were presented at the Cornell gathering. A. Kliore of JPL reported the detection of a tenuous ionosphere on this satellite determined when Pioneer 10 passed behind the moon on its way around Jupiter. The composition of Io's extremely thin atmosphere (the surface pressure is probably less than one billionth of Earth's atmosphere) is unknown but in part it may consist of sodium atoms — an intense and variable cloud of excited sodium atoms around Io was discovered by Bob Brown of Harvard University two years ago. Since then the properties of this sodium cloud have been determined more precisely by extensive studies at a number of observatories. It has been found that this cloud contains hydrogen and helium atoms as well.

The origin of this Io-associated cloud is intimately connected with the radiation belts of Jupiter. Io is the only one of the Galilean satellites which moves through the intense inner region of the radiation belts. Its surface is therefore continuously subjected to impacts of high energy charged particles — mostly electrons and protons. Atoms are probably knocked loose from the surface (a process called sputtering) and some, of sufficient energies to escape the relatively weak gravitational pull of Io, go into orbit about Jupiter as tiny satellites themselves. The other major satellites of Jupiter are presumably sufficiently removed from the intense portions of the radiation belts and are not subjected to this treatment.

The surface composition of Io is still a mystery. A pure water frost has been ruled out. Fraser Fanale, Torrence Johnson and Dennis Matson of JPL believe that the surface may be largely covered with sodium rich and sulphur rich evaporite deposits produced when salt-saturated ice or water sublimed or evaporated from Io's surface. The strongest piece of evidence in support of this view is that the JPL group has been able to isolate this type of evaporite material from the Orgueil meteorite (a Type I carbonaceous chondrite), and the reflection spectrum of this material matches Io's well.

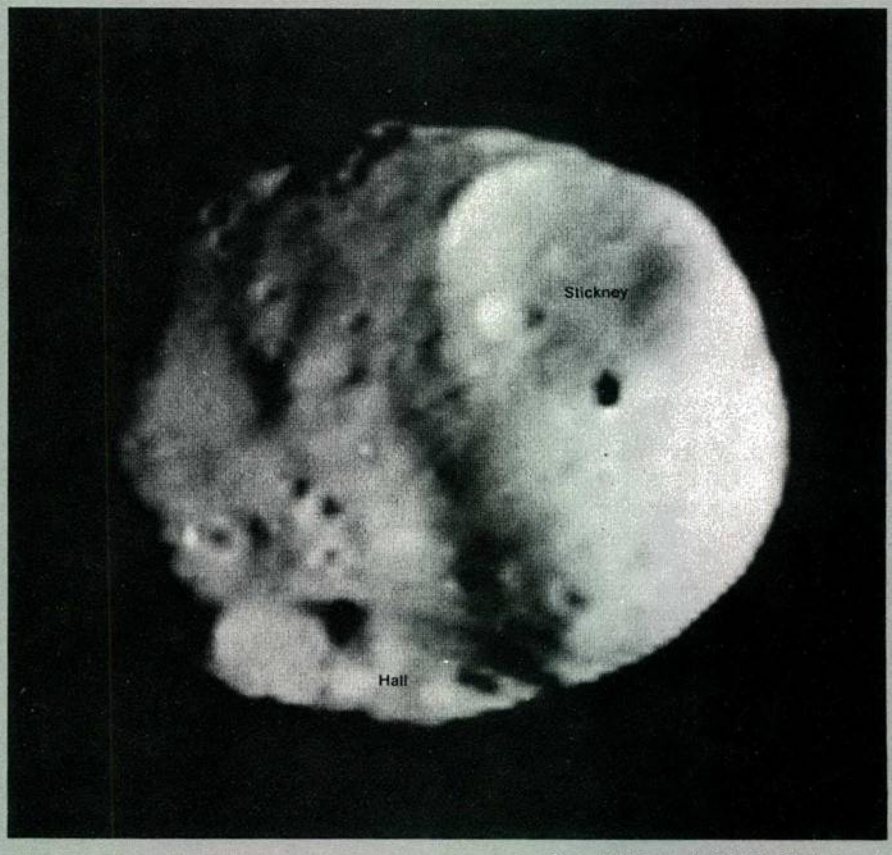
Many recent investigations of Saturn's family of 10 satellites were reported at the Cornell gathering. Perhaps the most significant of the new findings is the new diameter determination for Titan, making that moon the largest in the solar system. Details of this discovery are given in a companion article on page 56.

Among the most puzzling objects in the solar system is Saturn's ninth satellite Iapetus, an intriguing moon whose brightness changes by 1.7 magnitudes as it revolves about Saturn. When west of the planet it is magnitude 10.2, but east of Saturn the moon mysteriously drops down to 11.9. Explaining this curious phenomenon has kept astronomers scratching their heads for decades — and they still don't have an answer. However, David Morrison and his co-workers at the University of Hawaii proposed a model of this satellite which explains available brightness observations. Iapetus is assumed to have two quite distinct hemispheres in the Morrison model — one dark and the other bright. The dark side reflects about five percent of sunlight falling on it and the bright side about 35 percent. The question is: What is the dark and light material?



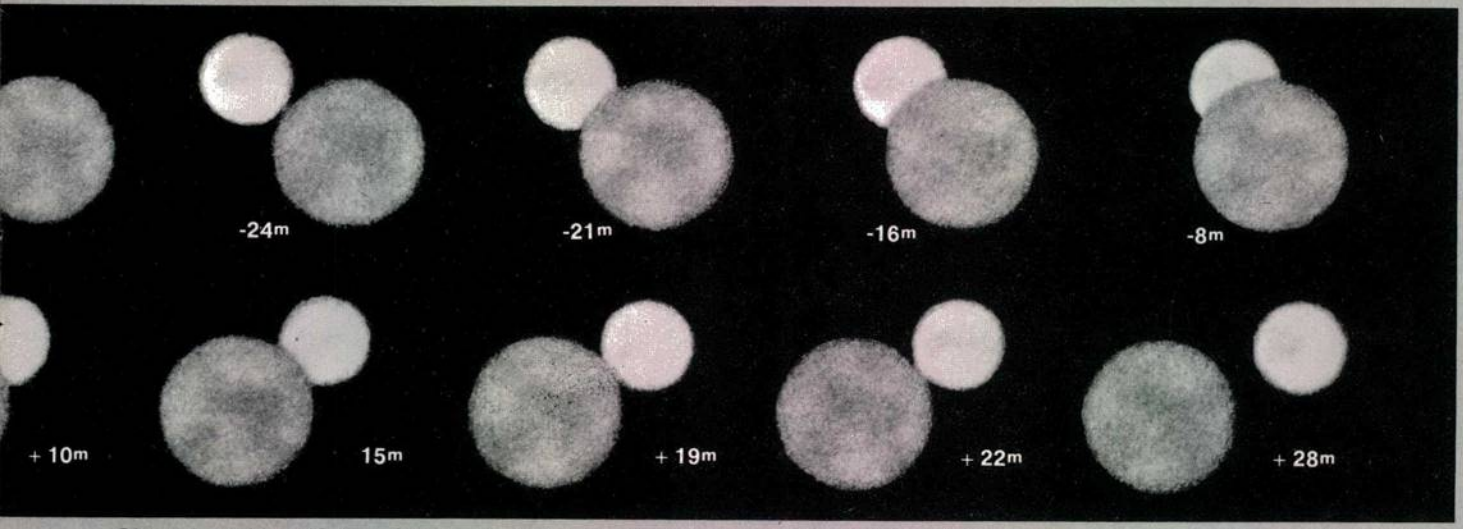
Meudon Observatory Illustration

Even though the albedo of the two faces of Iapetus differ by a factor of seven to one, their surface texture is probably similar according to polariza-



Cornell University/NASA Photograph

Phobos, the larger of the two tiny Martian moons, has been mapped over most of its battered surface thanks to photos such as this taken by Mariner 9 in 1971-72. The major Phobos features now have official names. The prominent crater near the south pole is named after Asaph Hall, the discoverer of Phobos, while the largest crater (five miles across) is named after his wife, Angelina Stickney, whose persistent encouragement was an important ingredient in the discovery. The side of Phobos shown in this photo is the same one that faces Mars. An amateur astronomer's telescope on the surface of Mars would show the same orientation and features seen here. From Earth, this moon is a 12th magnitude pinpoint.



Observing with a 43 inch Cassegrain reflector, John B. Murray distinguished detail on two of Jupiter's major satellites during a rare partial occultation. The sequence of drawings shows the brilliant 1,925 mile wide Europa being partially covered by the much larger and duller satellite, Ganymede (3,275 miles in diameter). Murray was able to distinguish detail on both moons. Seeing detail on the moons of Jupiter is exceedingly difficult. Even the giant moon Ganymede is smaller in apparent diameter than the distant planet Neptune. (See page 57 for a Pioneer 10 photo of Ganymede.)

tion measurements by Ben Zellner of the University of Arizona. Thus the dark or light side cannot have a special coating very different from the opposite hemisphere.

Observations of Iapetus by a joint University of Hawaii - Cornell group show that its brightness increases steeply near opposition — that is, around the time when it is virtually fully illuminated as viewed from Earth. This indicates a very porous surface texture — in fact the surface layer of Iapetus is probably more porous and intricate than the surface of the moon.

But none of this explains the brightness changes. There are, naturally, several theories kicking around that nobody is completely satisfied with. One suggests that the dark side of Iapetus is lightly coated with a carbon type material while the other side is coated with ice. The ice at one time covered the entire satellite but then got coated by some dark material. The dark hemisphere of Iapetus is the one that is facing the direction that the satellite is orbiting around Saturn, so anything in the satellite's vicinity would be deposited only on that leading side — hence the dark face.

But why don't the other satellites show the same effect? Why does Iapetus get singled out as the only satellite with a thin coating of dark stuff on its leading hemisphere? And does the superporous material that seems to cover both hemispheres have anything to do with the brightness variation?

At the present time nobody knows, and as Joe Veverka of Cornell University pointed out, "Even if we do find out, will it help us to understand the rest of the solar system?"

For this reason planetary astronomers are hesitant to spend a great deal of time on difficult experiments in attempts to determine just what is going on on Iapetus.

Saturn's second largest satellite, Rhea, was recently observed by near infrared instruments and the measurements indicate that its surface is covered with water frost. At least three satellites are definitely known to be in this category: Extensive water frost covers two Jupiter satellites — Europa and Ganymede — according to observations made over the last few years. From general considerations it has been argued that water frost is one of the most likely surface materials for all the larger satellites of the outer planets. Observations over the next few years are going to be centered on making this determination.

Several years ago visual observers were attempting to map the surface features of the major satellites of Jupiter and they noted that the equatorial regions of Io are lighter than the polar regions. This visual observation has been confirmed photographically as you can determine for yourself by turning to page 45 of the September 1974 issue of ASTRONOMY. The lower photograph on that page distinctly shows the shadow of Io and immediately to the right of the shadow the image of Io itself. Close examination of that pale yellow satellite will show that it appears egg shaped. What we are seeing is the bright equatorial zone, while the slightly darker polar zones are the same color as the belt of Jupiter directly behind the satellite.

More and more cases of visual observations being confirmed by photography, and other detection techniques are cropping up in planetary astronomy. However not all visual observations are confirmed, and therefore proceeding on the basis of observations made with the eye alone is often only reluctantly done.

Funds Not Fully Restored

A large telescope high above the obscuring effects of Earth's atmosphere has been the dream of many an astronomer whose observations were wrecked by bad seeing or weather. For several years, plans have been on the drawing boards for a 120 inch telescope — equivalent in size to the third largest instrument on Earth — to be launched into Earth orbit in the early 1980s.

Once in orbit, the telescope would far surpass the performance of its earthly counterparts which are subjected to constant distorted images due to our blanket of life sustaining air. Estimates vary but some astronomers optimistically predict the Large Space Telescope could detect objects as faint as 29th magnitude — 1,000 times fainter than anything seen from Earth.

NASA had requested $6.2 million to advance the telescope to the serious research and design stage in 1975, but funds were totally cut off by the Appropriations Committee of the House of Representatives. Now a Senate-House compromise has been worked out with only $3 million of the $6.2 million being approved. NASA was also instructed to consider "a less expensive project to be launched at a later date".

Quasars Aid Down-to-Earth Project

Radio signals from outside our galaxy will soon be used to detect almost imperceptible movements in Earth's crust that may lead to the accurate prediction of earthquakes.

A team of scientists and engineers at NASA's Jet Propulsion Laboratory (JPL) in Pasadena Calif., aided by geophysicists from the California Institute of Technology, is developing an Earth-fault monitoring system which combines experience gained from spacecraft navigation with current radio astronomy and geophysical research. The earthquake research concept is called ARIES (Astronomical Radio Interferometric Earth Surveying).

By the end of 1974, a sensitive radio receiver linked to a 30 foot antenna at JPL will be listening to signals from quasars as far away as a billion light-years. Listening to the same radio source will be the 210 foot antenna at the NASA/JPL Deep Space Network at Goldstone, Calif.

The key to the ARIES project is the capability of measuring the difference in arrival times of the identical quasar radio signals at the two antennas, located about 125 miles apart. About 20 quasars will be used as "benchmarks" in the sky.

Over the last three years, based on instruments originally designed for space exploration, ARIES techniques have been developed to produce time difference measurements to a precision of about 1/10 of a billionth of a second. From this type of measurement the distance between the antennas can be determined to an accuracy of inches and less.

The initial distance measurement between JPL and Goldstone will establish a reference base line. Subsequent measurements will indicate any change in the distance between the two antennas that might be caused by shifts in Earth's crust adjacent to fault zones, over a period of years. A straight line between Pasadena and Goldstone intersects the San Andreas fault, the main channel of Earth's fracture system in California, and source of that state's most devastating earthquakes.

Motion associated with the fault in any or all of three dimensions can be measured. It is this motion that creates the strain that is eventually relieved as a mild or sometimes violent earthquake.

The accuracy goal of these first distance measurements between antennas will be four inches, with a later accuracy goal of less than one inch.

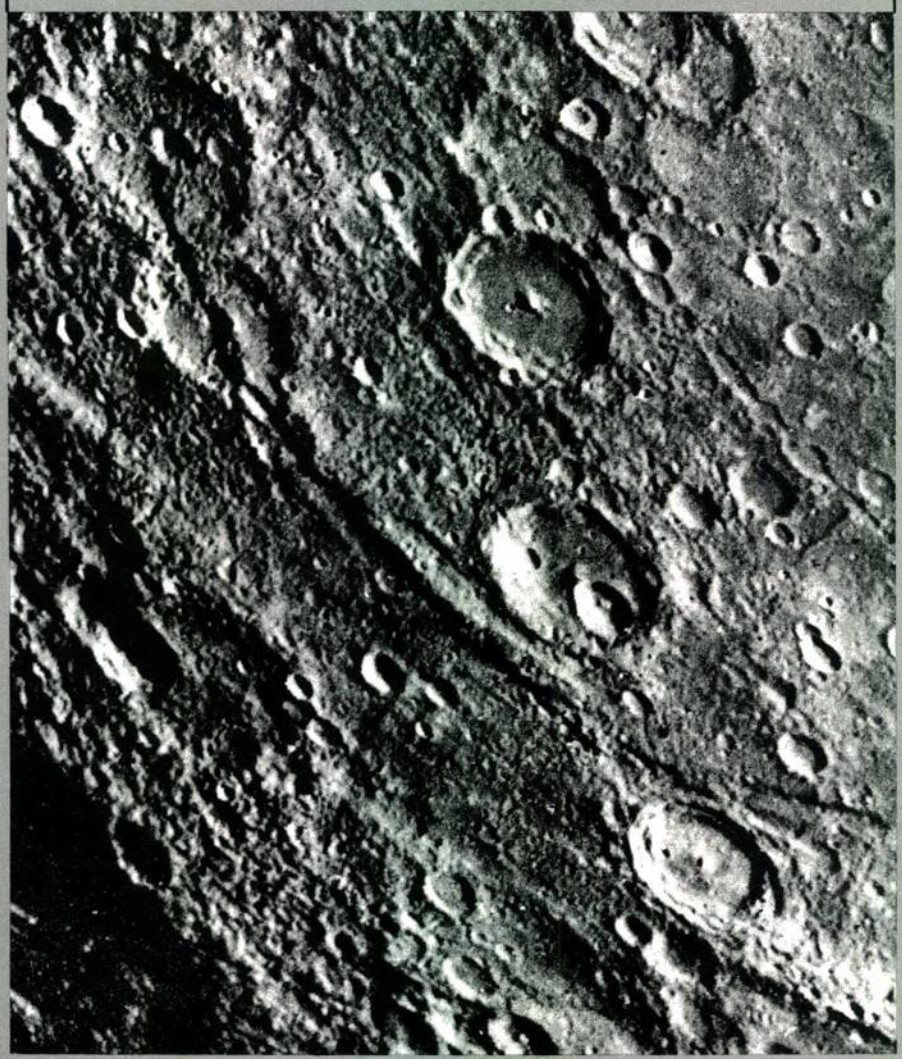
In measuring the motions of Earth's surface in three dimensions, ARIES may also be useful in seeking confirmation of a new theory that suggests that some earthquakes are preceded by a swelling of Earth's surface up to three feet over hundreds of square miles. This rock dilatancy (expansion) theory is based on the belief that stresses in the crust cause minute cracking of rocks on a vast scale that eventually lifts the surface.

The cracking would explain changes in the velocity of seismic waves that have been recorded in the United States, Japan, and the Soviet Union. It is believed that minute cracks, on a large scale, slow the transmission of seismic waves through crustal rocks. Filling of the cracks by underground water would then accelerate the waves back to original velocities.

If the project can provide data showing that Earth's surface does swell upward in advance of some earthquakes, science may have a major new tool in earthquake research and ultimately in prediction techniques.

ARIES also promises to provide current data on continental drift (the movement of the immense plates that form Earth's crust). The motions of the plates have been calculated, but only over periods of millions of years. ARIES is expected to make direct measurements of the present day motion of the two plates that meet at the San Andreas fault.

Second Visit to Mercury



NASA Photograph

On its second visit to Mercury, Mariner 10 photographed a rugged cliff that extends over about 200 miles of the planet's south polar region. Similar features have been photographed elsewhere on the planet and are believed to be ruptures due to internal compressive forces that shrank Mercury's outer layer during the final stages of the planet's formation. The spacecraft was 40,000 miles from the smallest planet when this photo was taken on Sept. 21, 1974.

New Stars Found in Orion Nebula

A cluster of embryonic stars less than 100,000 years old has been discovered near the center of the Great Nebula in Orion. The stars are invisible and cannot be studied by optical astronomers, but can be detected by their infrared heat radiation.

Associated with the infrared objects — there are five of them — is a very much larger cloud of molecules producing intense radiation from excited carbon monoxide gas. Heat from the newly formed stars may be causing the strong emissions from the cloud.

The embryo stars were discovered by Ian Gatley of the California Institude of Technology and Michel Penston of England's Royal Observatory using sensitive infrared detectors attached to the Mt. Wilson Observatory's 100 inch telescope.

The cluster is the second grouping of presumed embryo stars found in the Orion nebula. (The nebula is a great glowing dust and gas complex in our Milky Way galaxy; it covers a span of some 26 light-years.) The previously known cluster was discovered by infrared astronomy at the Hale Observatories and the University of Arizona, and is also contained in a molecular cloud.

"Until the new discovery, the relationship between the embryo stars and the molecular cloud was unclear," said Eric Becklin, another member of the Caltech-Hale Observatories infrared group. "Now it appears certain that in both cases the infrared sources are very young, having been recently formed within their associated molecular clouds."

Stars are believed to form in clusters from dense condensations in gas and dust clouds. Later they are expected to drift gradually out of the cloud. These two sets of objects are still "sitting" in their clouds, indicating that they are very young.

The new cluster covers a total area of 1/2 light-year (about three trillion miles). The individual objects vary in size but average some 450 million miles in diameter. The objects are invisible optically because they lie deep inside the molecular cloud. The visible light they give off is absorbed by gas and dust in their vicinity and turned into infrared radiation. A small amount of the infrared radiation from the vicinity of the stars is absorbed by dust particles mixed with the gas in the extended molecular regions, providing the mechanism by which the newly formed stars may be heating the molecular clouds. (A new Kitt Peak Observatory photograph of the Orion nebula appears on page 32.)

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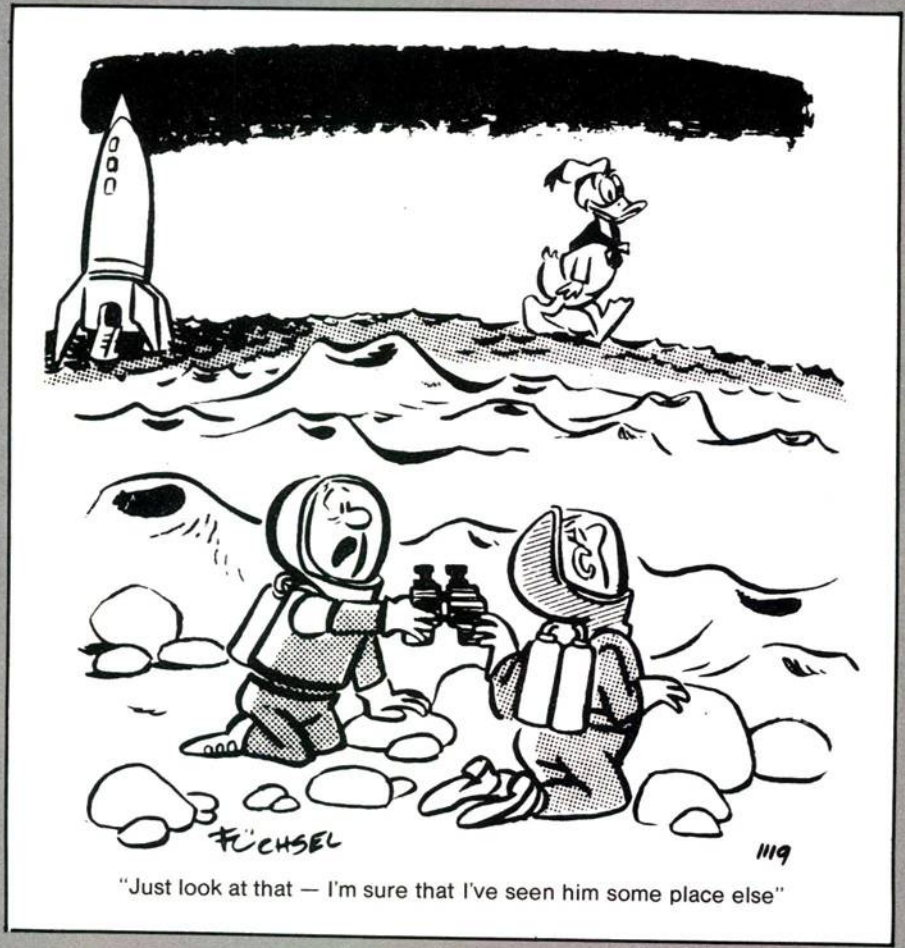

"Just look at that — I'm sure that I've seen him some place else"

Global Radio Telescope to Operate Soon

The techniques for studying the sizes and structures of distant radio emitting objects in the universe (galaxies and quasars) using radio telescopes separated by thousands of miles have progressed so far that serious consideration is now being given to the construction of a permanent network of radio telescopes covering our planet. The signals from these telescopes would be tape recorded and later processed at a central computer to make maps of radio galaxies and quasars with a resolution of better than 1/1000 of a second of arc.

A more sophisticated version might eventually send signals from each telescope directly to the central computer by means of a satellite link. A prototype system would contain nine telescopes spread over the United States to Hawaii. Later, telescopes in Europe and the USSR would be added to increase its power.

A group of U.S. radio astronomers is now working out the details of such a giant synthesis radio telescope. It will enable us to "see" and photograph radio objects in incredible detail — greater than could ever be achieved at optical wavelengths.

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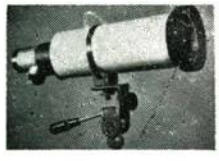

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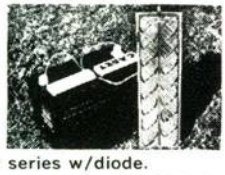

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This staunch leader of the Dynascope line has won widespread recognition from schools, colleges, and professionals, as an outstanding achievement in a 6-inch telescope. Since it was introduced a few years ago, our files have become filled with complimentary letters from excited amateurs and professionals all over the country. Each one is truly amazed at the superior optical performance of this RV-6 6-inch Dynascope! Here is large aperture in a quality instrument at a price that compares with many 4-inch telescopes. *And this low cost includes such exclusive extra features as electric drive* (patented), *setting circles, and rotating tube!* There are no "extras" to run up your cost!

The superb optical system resolves difficult objects with definition that is absolutely breathtaking. The close tolerances of the precision construction assure an accuracy and smoothness of operation once associated only with the finest custom models. The heavy-duty mount, complete with electric drive, provides the stability so essential for satisfactory viewing, yet there is easy portability, because in a matter of minutes the entire telescope can be dismantled into three easy-to-handle sections.

Only Criterion's engineering ingenuity, coupled with volume production and modern manufacturing methods, makes this handsome 6-inch model available at such reasonable cost. You can order it with complete confidence that it will live up to your expectations in every way, for this assurance is *guaranteed* under our full-refund warranty. Send your check or money order today. Or use our liberal time-payment plan and take months to pay.

Orders for the RV-6 Have Set New Records!

Demand for this fine instrument, so well proved in use, has been soaring, as more and more serious telescope buyers have come to realize, by comparison, what an extraordinary value it is. To keep pace, we hurried along a planned expansion into facilities more than three times as large as before.

We stepped up production as rapidly as we could—but remember, this is a precision, handcrafted instrument, individually built to our exacting standards, and individually guaranteed. In addition, our industry like most others has had to contend with shortages. At times, critical materials have just not been available. In spite of all efforts, order backlogs grew, and we have felt obliged to offer refunds to anyone who did not want to wait. (Very few accepted —which itself is significant.) Today our backlog has been brought down a great deal, though we must still reluctantly keep you waiting a while. Our apologies...but it is comforting to know that when your telescope arrives, it will be in every respect the easy-to-operate, outstanding performer you ordered—an RV-6 Dynascope.

You Could Pay $100 More Without Getting All These Superior Features (Except on Another Dynascope)

1. EXQUISITE OPTICAL SYSTEM INCLUDES f/8 6-INCH PARABOLIC MIRROR made of **PYREX**-brand glass, accurate to better than ⅛ wave, zircon-quartz coated, and guaranteed to reach the theoretical limits of resolution and definition. Teamed with elliptical diagonal mounted in 4-vane adjustable spider.

2. NEW DYN-O-MATIC ELECTRIC DRIVE with smooth self-acting clutch that engages and disengages automatically as you seek different objects. Will not interfere when manual operation is desired. Safety housed case. Plugs into ordinary AC socket.

3. TWO EYEPIECES: Achromatic Ramsdens **70X** (18 mm.), **140X** (9 mm.). Also available: **100X** (12.7 mm.), **180X** (7 mm.). Achromatic Ramsdens, $14.95 each; **220X** (6 mm.), **320X** (4 mm.). Orthoscopics, $18.50 each.

4. SOLID NEW EQUATORIAL MOUNT, extra-reinforced design to provide pillarlike stability. No annoying side play or wobble. Adjusts easily to any latitude.

5. SETTING CIRCLES for both right ascension and declination. Handsomely engraved and finished in fine aluminum.

6. 6 x 30 FINDERSCOPE, ACHROMATIC, COATED, with accurate cross hairs and fine focus. Durable cast-aluminum bracket with 6 adjusting screws allows positive collimation.

7. ROTATING TUBE FOR MAXIMUM VERSATILITY AND VIEWING COMFORT. Solid-cast chrome-finished rings are generous 1″ wide with felt lining. Newly designed construction, with oversized knurled adjusting knobs, affords maximum rigidity and allows quick disassembly and portability, with or without tube.

8. STRIKINGLY HANDSOME WHITE 50″ BAKELITE TUBE with porcelainized Duralite finish, durable yet light. Walls are ⅛″ thick, completely insulated and anti-reflective blackened inside.

9. BRASS RACK-AND-PINION EYEPIECE HOLDER has precision-cut rack and gear for easier, smoother, more positive focusing. Takes standard 1¼″ oculars, negative or positive.

10. STRONG, VIBRATION-FREE, ALL-METAL TRIPOD with easily removable legs. Provides sure, steady support, plus lightweight portability.

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Manufacturers of Quality Optical Instruments

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☐ Please send me, under your unconditional guarantee, the RV-6 6-inch Dynascope. Payment of $219.95 plus $15.00 crating charge is enclosed.

☐ Send FREE ILLUSTRATED LITERATURE describing the RV-6 6-inch Dynascope and all the telescopes in the Dynascope line.

☐ Send FREE ILLUSTRATED LITERATURE on your new DYNA-TRACKER™ Variable-Speed Control for RV-6 or other electric-drive telescopes.

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